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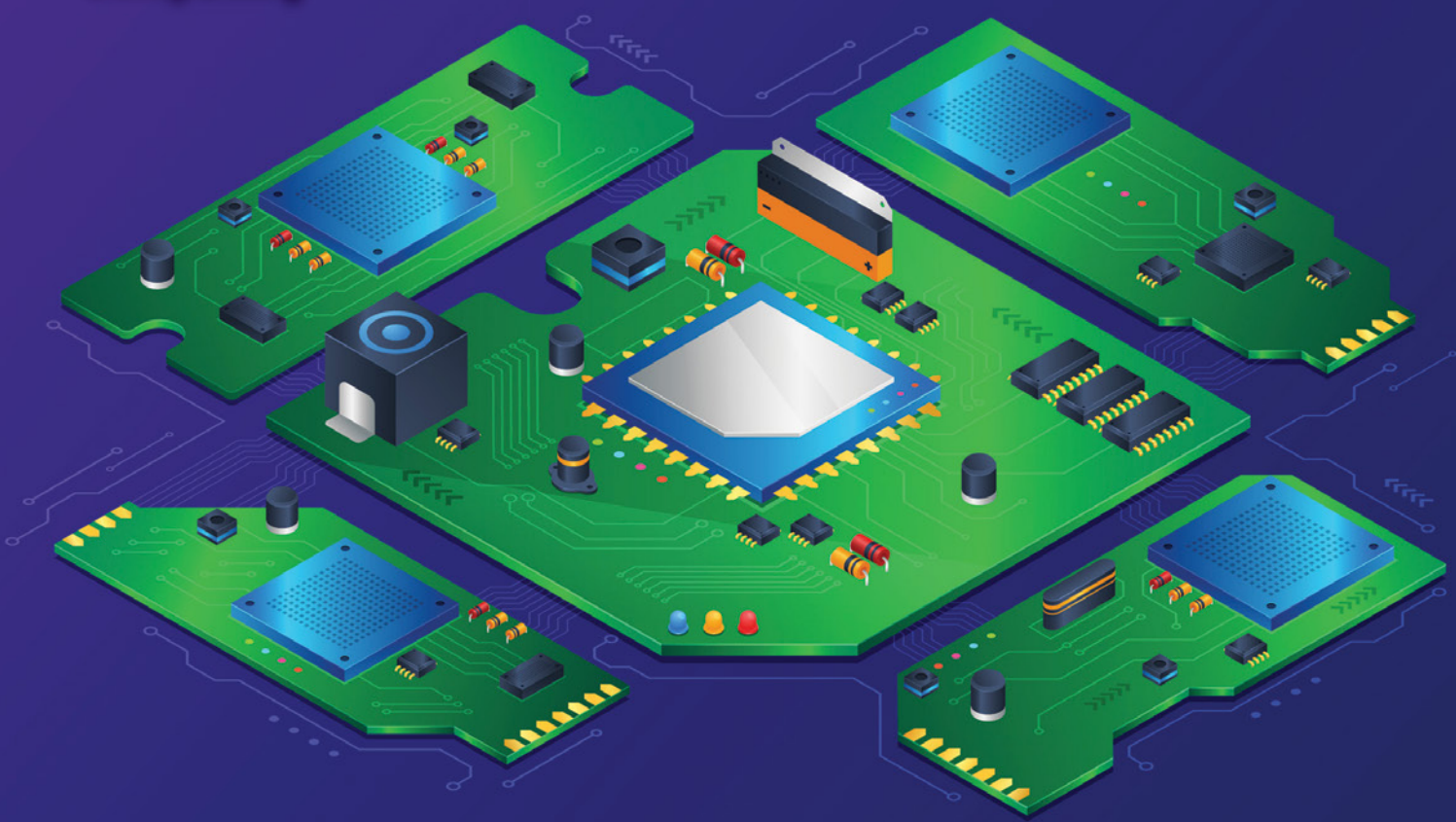

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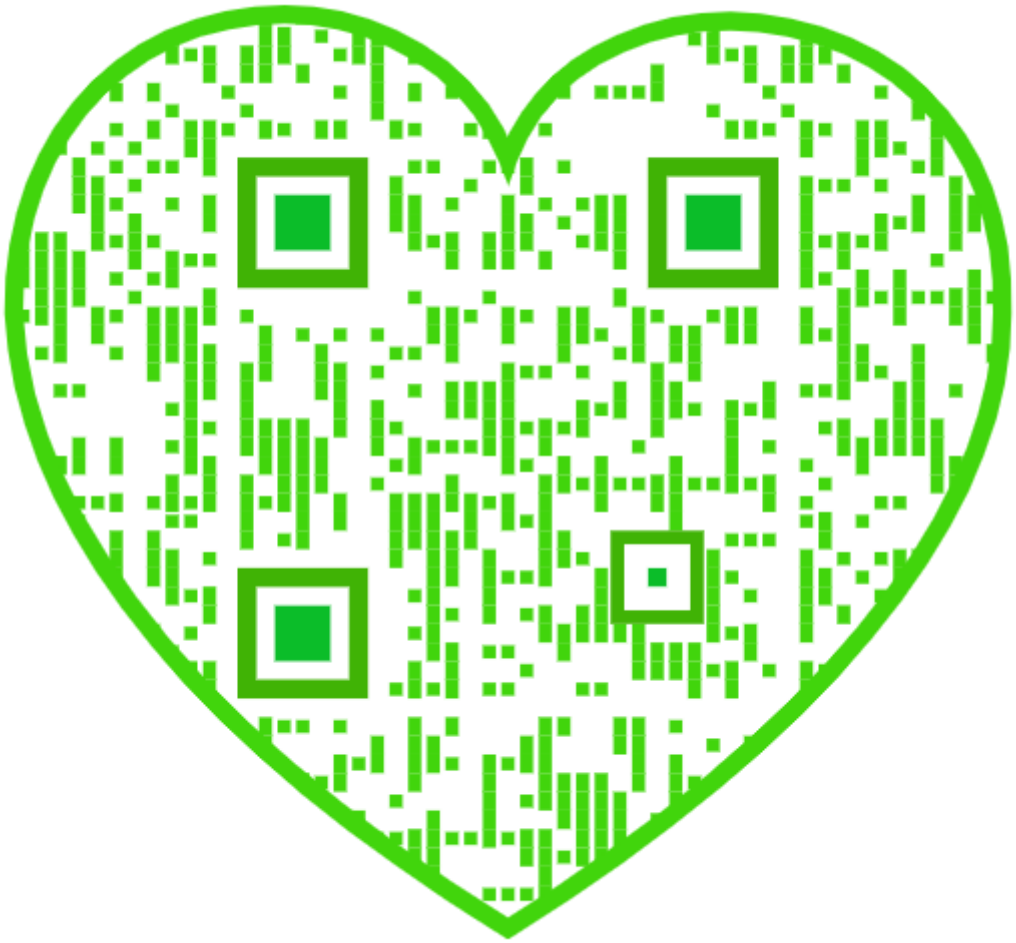

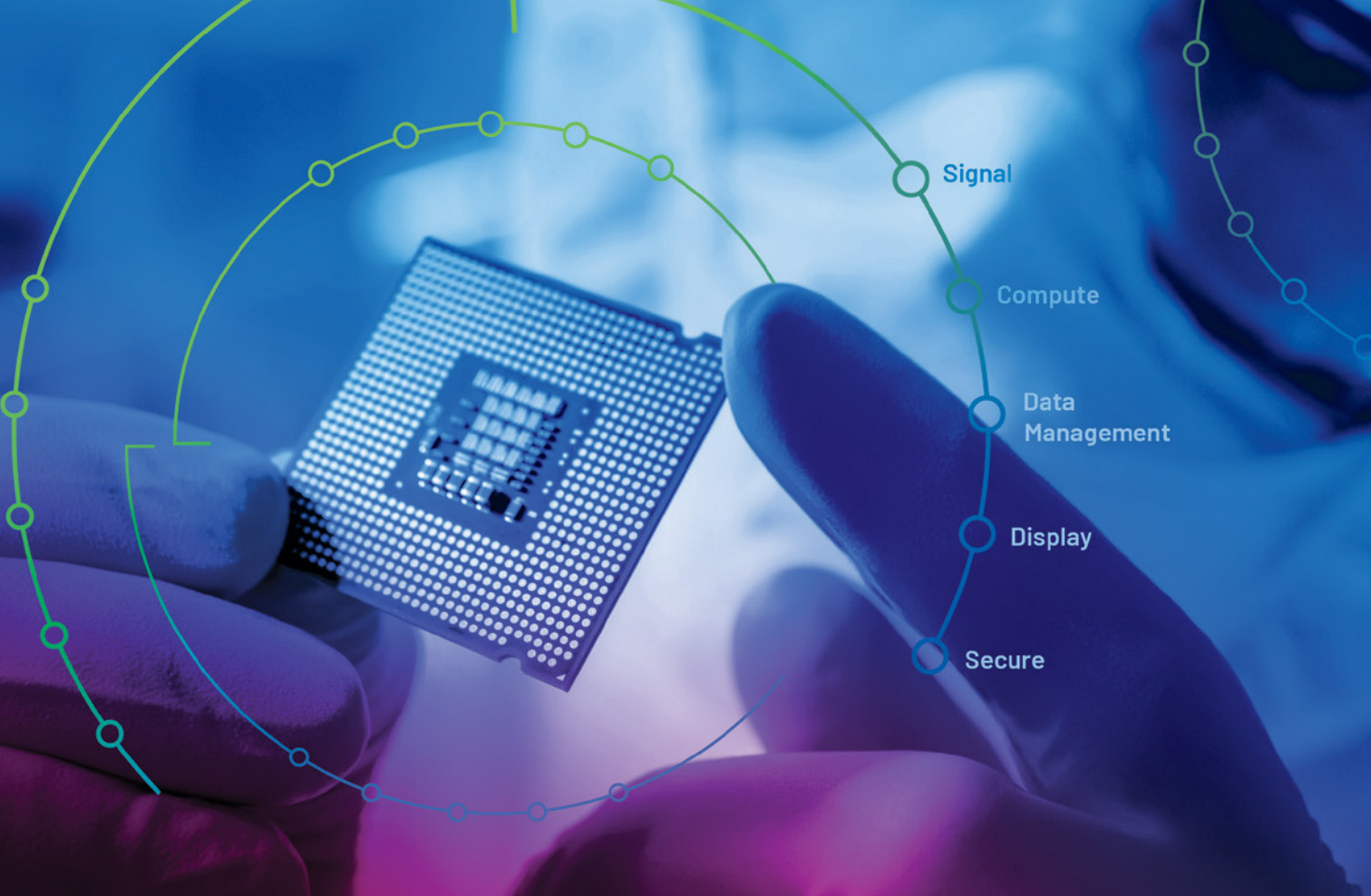

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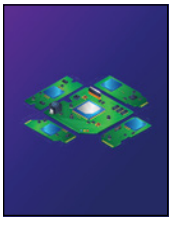

Modern aerospace and defense systems demand compact solutions without compromising capabilities. Existing mezzanine cards, like XMC, were not designed to meet these stringent SWaP requirements, posing significant obstacles. To learn how a new embedded computing standard, VITA 93, is helping system designers meet modern bandwidth, size, and flexibility requirements, read the feature article on page 4.

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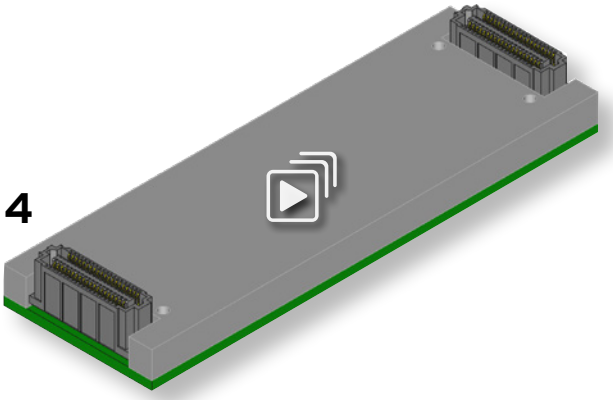

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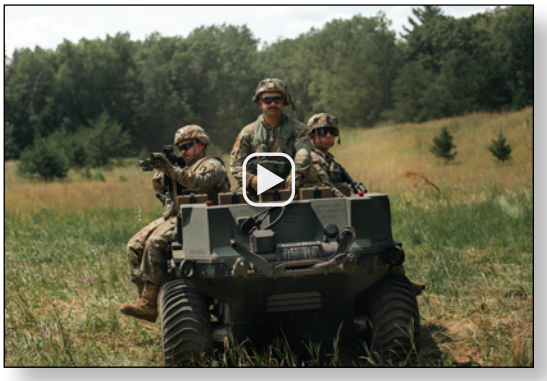

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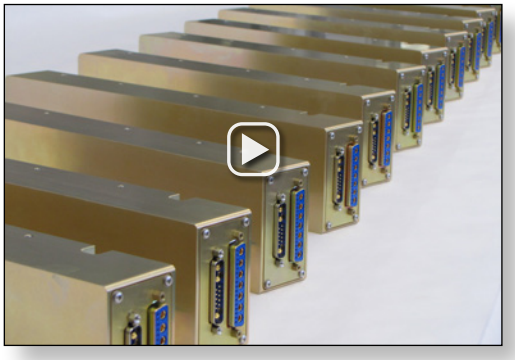

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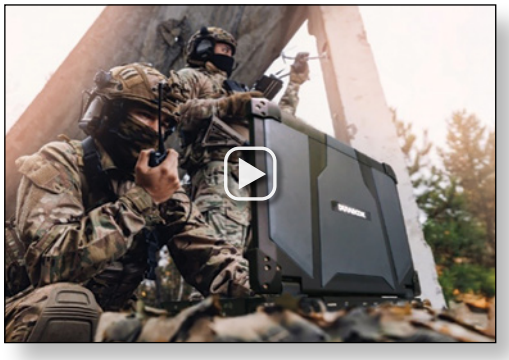

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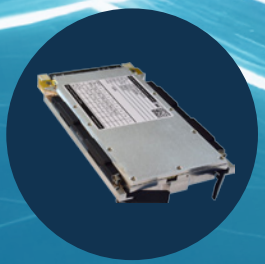

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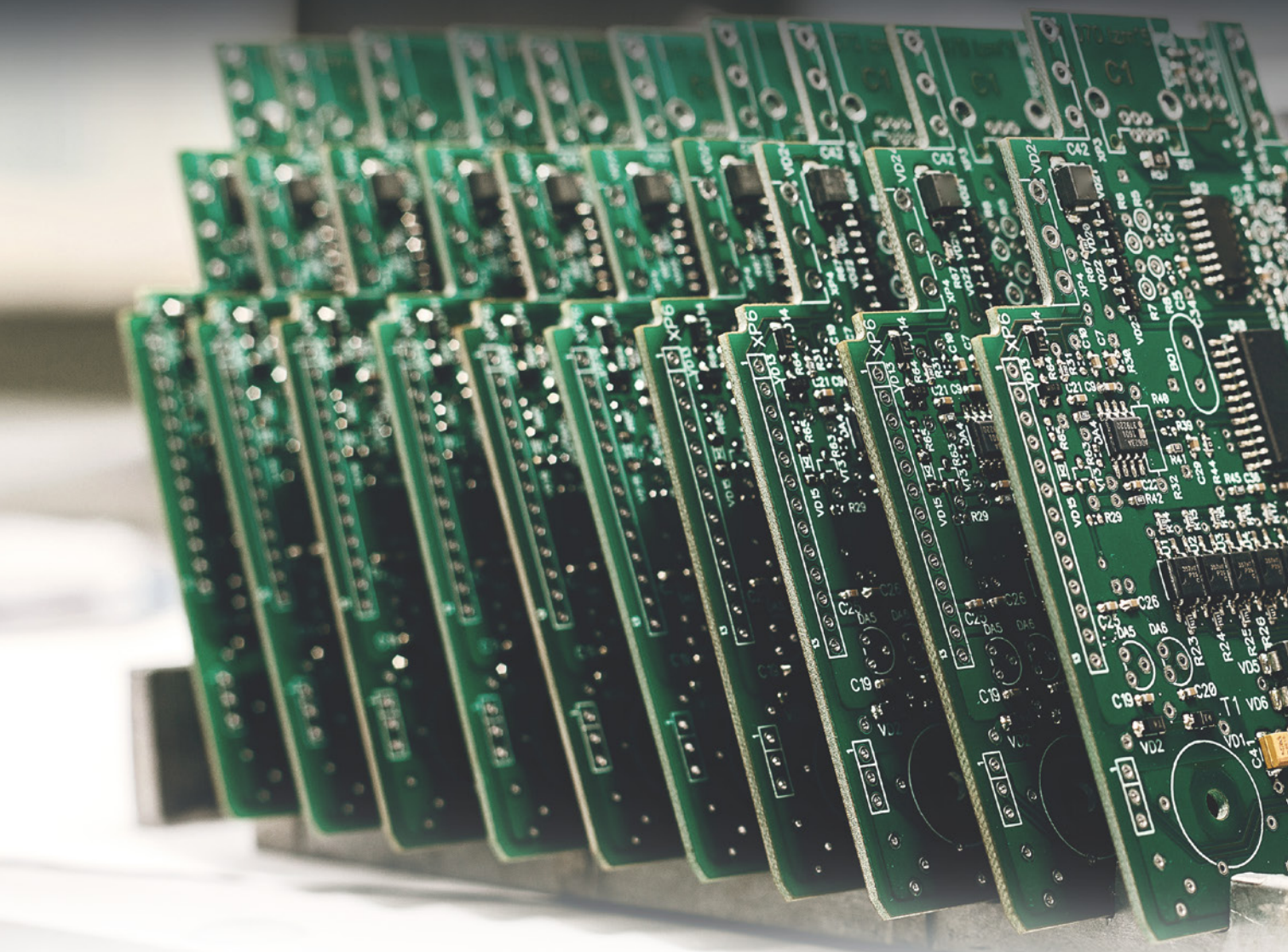
Advancing Embedded Systems with VITA 93: A New Era in Modular I/O for Aerospace and Defense

Aerospace and defense system designers are demanding scalable and high-performance I/O solutions. While traditional mezzanine standards have proven reliable, they often fall short of meeting modern bandwidth, size, and flexibility requirements. This challenge is particularly evident in aerospace and defense applications where high-speed data processing must align with stringent size, weight, and power (SWaP) constraints.

Current mezzanine solutions also face significant limitations in scalability, thermal management, and I/O density. These constraints can lead to compromised system performance and limited upgrade paths in applications where adaptability is crucial. This article explores how the new VITA 93 (QMC) standard addresses these challenges through its innovative QMC architecture, enabling unprecedented flexibility, scalability, and rugged reliability while maintaining



compatibility with existing and future systems. It also covers how VITA 93 (QMC) builds on lessons learned from previous standards, blending their best features with new capabilities for the future.

In this article, system architects and design engineers will learn how evolving embedded system requirements are driving the need for flexible mezzanine solutions. Additionally, the challenges of traditional mezzanine standards and their impact on system design are outlined. Practical advantages of VITA 93's modular architecture, including scalability from single- to quad-size implementations are also provided. The article also explains where QMC fits into the VITA ecosystem, benefits for single-board computer (SBC) and carrier designers, and how to leverage VITA 93 for future embedded system designs. Finally, readers will learn about the technical innovations of QMC, including advanced cooling options and high-speed interfaces.

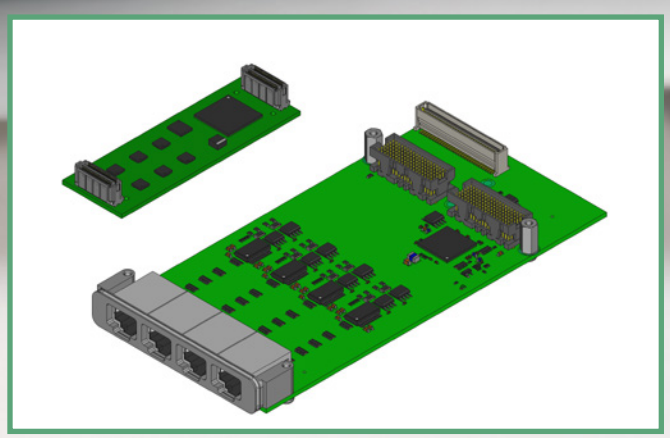
Traditional Limitations

VITA 93 (QMC) builds on existing technology while addressing inherent challenges in current mezzanine card standards such as PMC and XMC. These issues include size, compatibility, thermal management, and limited expansion capabilities.

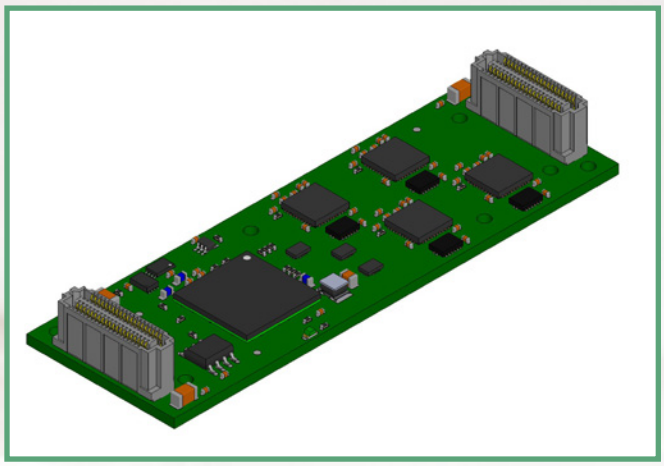
Modern systems demand compact solutions without compromising capabilities. Existing mezzanine cards, like XMC, were not designed to meet these stringent SWaP requirements, posing significant obstacles in aerospace, defense, industrial, medical and transportation sectors.

As Dean Holman, President and Executive Director of VITA, notes, "The circuit boards used in older PMC and XMC designs are simply too large for today's compact systems."

With current mezzanine-card standards, system integration can sometimes become difficult: Air-cooled and conduction-cooled XMC cards are based on different designs and provide multiple I/O options. These factors mean that designers



VITA 93 (QMC) enables solutions for reduced-SWaP applications. A base single QMC measures just 26 mm by 78.25 mm, providing an optimal balance between component density and space efficiency. Compared to XMC modules it is substantially smaller, making it ideal for I/O interfaces in reduced-SWaP applications. (Image: TEWS Technologies)



TQMC400 – Single size QMC: The first QMC module being released by TEWS Technologies. (Image: TEWS Technologies)

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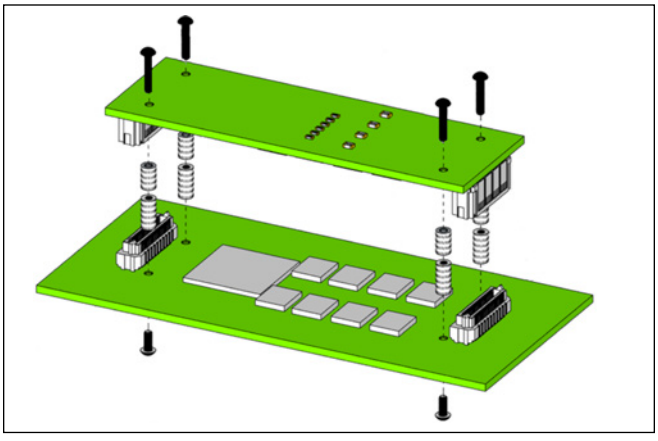


Depiction of an air-cooled QMC on a carrier card. (Image: TEWS Technologies)

must spend extra time and effort ensuring everything will work together and sometimes have fewer options than they'd like.

Getting the heat off the cards can also be problematic. As field programmable gate arrays (FPGAs) and application specific integrated circuits (ASICs) become more powerful, they generate substantial heat, which current mezzanine cards often struggle to dissipate efficiently.

Additionally, the increased complexity and requirements of today's systems leads to the need for system-health monitoring. Current mezzanine standards like XMC come only with a half-hearted approach to Intelligent Platform Management Interfaces (IPMI) and therefore require a higher integration effort.

Lastly, current mezzanine cards lack flexibility for growth as they come in fixed sizes – often too big – that cannot be easily changed, a situation akin to having a drawer that cannot be made bigger or smaller based on what you need to store. Engineers often end up either buying more capability than they need or not having enough space for all their requirements.

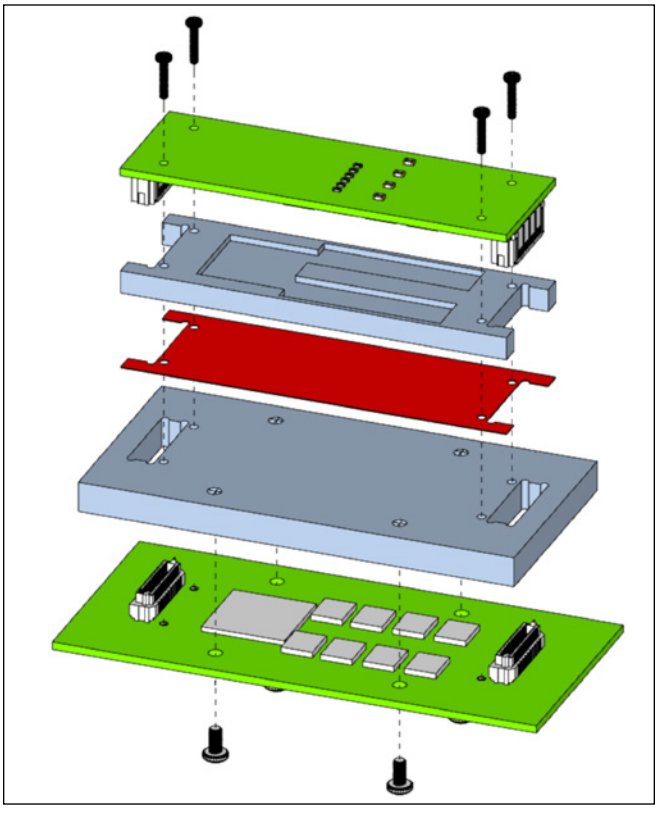
These challenges call for a new approach – one that is more flexible, can scale with changing needs, and works efficiently across different platforms. This is where VITA 93 (QMC) steps in.

Advancing Mezzanine Design

The VITA 93 (QMC) standard revolutionizes mezzanine-card technology, introducing a highly modular, flexible and scalable approach to I/O integration. Born from the VITA 90 working group's development of VNX+, this standard addresses the growing need for adaptable, high-density I/O solutions in modern embedded systems.

VITA 90 working group engineers realized they needed a new way to add I/O capabilities to their systems; they wanted something that was not just smaller, but also more flexible than existing solutions. While VITA 93 (QMC) was initially designed to work with VNX+, it was always the aim to develop a new standard that solves existing limitations and can be used in broad range of PCIe-based systems like VPX.

"With VITA 90, also known as VNX+, it became apparent we really needed small mezzanine cards – much smaller than the



Depiction of a conduction-cooled QMC on a conduction-cooled carrier card. (Image: TEWS Technologies)

mezzanine cards nowadays used on VPX," VITA's Holman explains. "The primary driver was being able to get something small enough to fit one or two of them on these really small-form-factor VNX+ boards."

This focus on size efficiency, combined with the need for more versatile I/O options, led to the development of the QMC specification – a design that is proving valuable across multiple industries and applications.

Smaller by Design

A base single QMC measures just 26 mm x 78.25 mm, providing an optimal balance between component density and space efficiency. Compared to XMC modules, it is substantially smaller, making it ideal for I/O interfaces in reduced-SWaP applications.

"For certain applications where the primary use of this might be an I/O interface, I think you can't get much smaller than a single QMC," Holman says. " I would say this is pretty close to what we can expect at least for the next 10 years."

VITA 93 (QMC) supports up to PCIe Gen 6, which offers significant bandwidth capabilities while maintaining backward compatibility in the small form factor. It supports as many as x16 PCIe lanes in quad QMC configurations. The standard leverages the AccelerateHD Connector system by Samtec, ensuring reliable performance for high-speed applications.

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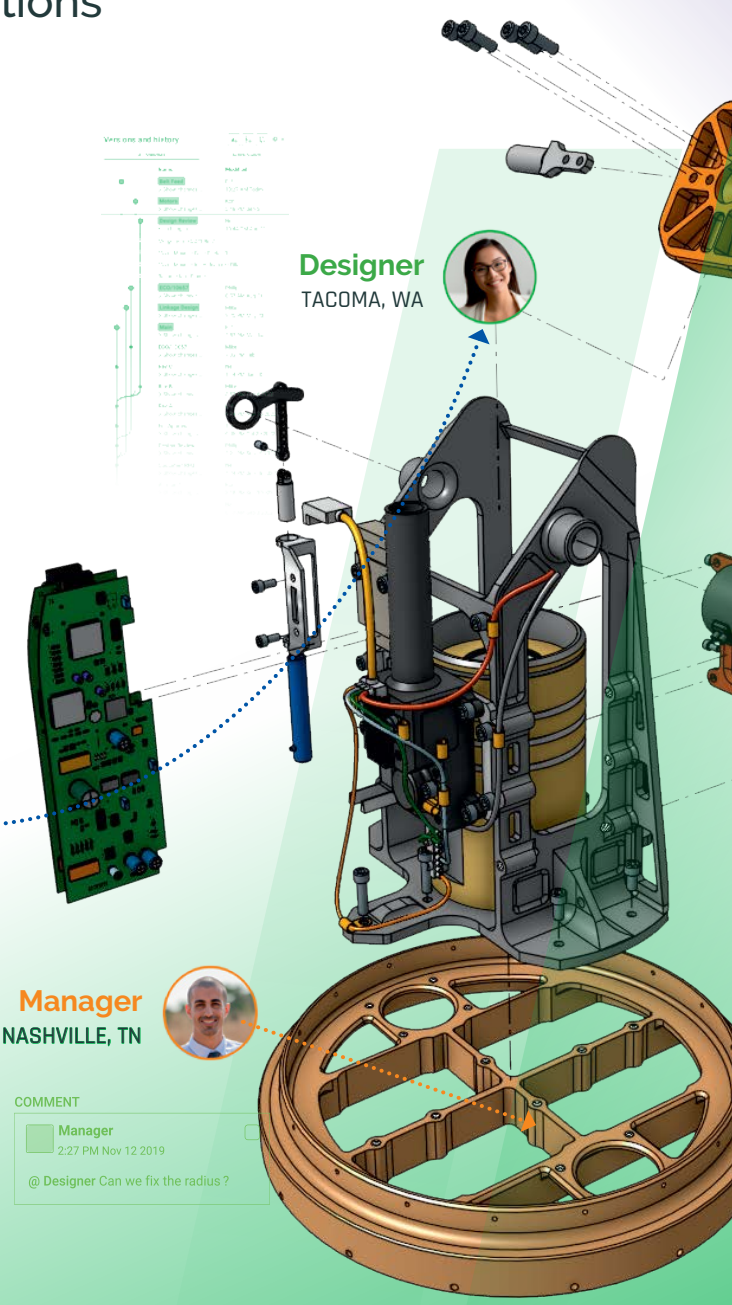

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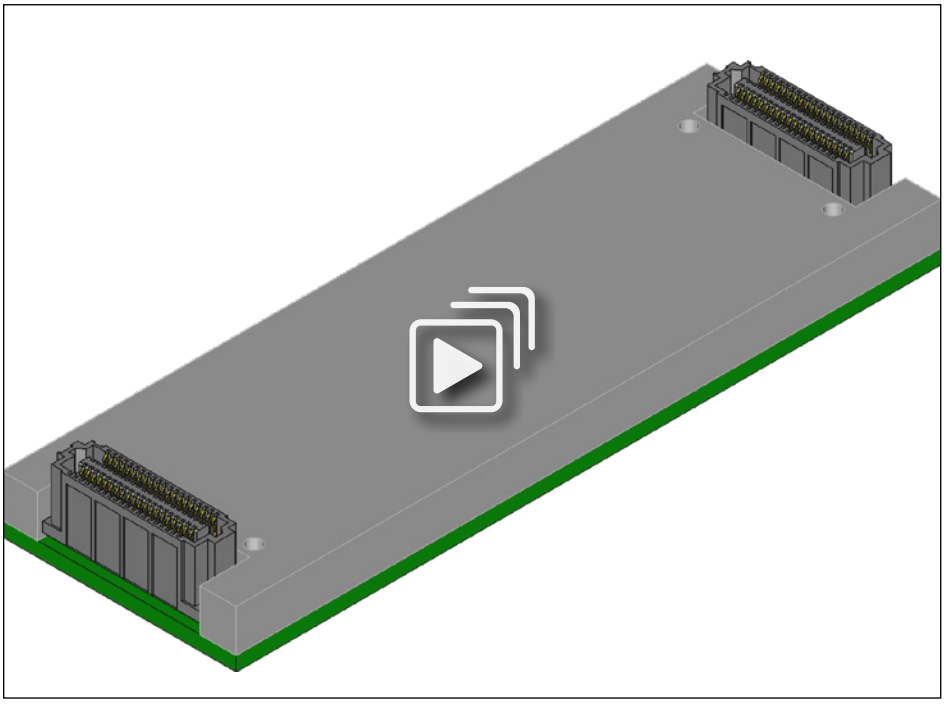

Single size conduction-cooled QMC with mounted heatsink. (Image: TEWS Technologies)

The total thermal design power per single QMC is almost 30 W. For a double, triple, or quad QMC, just multiply the thermal design power for a single QMC by two, three, or four.

Scalability

The QMC architecture offers unseen scalability as it defines four card sizes within the standard, enabling the design of QMC cards that can cover a whole range of applications, starting from simple I/O functionality on single QMCs up to the highest-complexity solutions with the need for high bandwidth and high I/O count. Designs start with PCIe x4 and 40 I/Os on a single QMC and can go up to PCIe x16 and 160 I/Os on quad QMC.

The standard scaling options include:

- Single QMC: PCIe x4 with 40 I/Os
- Double QMC: PCIe x8 with 80 I/Os
- Triple QMC: PCIe x12 with 120 I/Os
- Quad QMC: PCIe x16 with 160 I/Os

The 40 I/Os of a single QMC are organized into five I/O pipes each offering eight single-ended or four differential I/Os. Each I/O pipe comes with its individual ground supporting the integration of isolated interfaces.

Thermal Management

One of the key takeaways with VITA 93 (QMC) is that unlike previous standards like XMC or even PMC, the same card design can be used for either conduction- or air-cooled applications. In the past, that's always been somewhat difficult and users often ended up needing two different products, as these two cooling approaches didn't work together mechanically. That is not the case with VITA 93 (QMC).

Air-cooled and conduction-cooled QMCs are based on the same design. By adding a skyline heatsink to an air-cooled QMC it is converted to a conduction-cooled QMC. In addition, the conduction-cooling approach of VITA 93 (QMC) provides much better heat transfer from the QMC to the carrier than the XMC's conduction-cooling approach.

VITA 93 (QMC) ensures interoperability between vendors through a well-thought-out mechanical concept. All mechanical components required for the mounting of the QMC card have to be provided by the carrier manufacturer, which makes it possible to fit any QMC on any carrier, whether it's conduction-cooled or air-cooled, and independent of the QMC and carrier manufacturer.

With VITA 93 (QMC), system designers can optimize component placement and thermal management based on specific application requirements, as the standard defines variable stacking heights (9 mm, 11 mm, 14 mm, and 16 mm). The stacking height is solely defined by the carrier card, ensuring that all QMC cards will fit on the carrier card independent of the chosen stacking height and allows designers to most effectively use the PCB area underneath the QMCs.

Integration with VITA Ecosystem

VITA 93 (QMC) aligns seamlessly with other VITA standards like VPX and VNX+, offering a flexible, modular, and scalable I/O concept that enhances the entire ecosystem's flexibility.

"I think it fits in perfectly," Holman notes. "We specifically are structuring it so it supports VPX and other carrier-card standards, so everything that is being done now with 3U/6U OpenVPX can benefit from this."

Moreover, VITA 93 (QMC) fits into the ecosystems of other standards, including those developed by PCISIG [Peripheral Component Interconnect Special Interest Group] and PICMG [PCI Industrial Computer Manufacturers Group] – for example, PCIe and CompactPCI-Serial – broadening its applicability.

Benefits for Single-Board Computer and Carrier Designers

The VITA 93 (QMC) standard introduces several transformative advantages, marking a significant departure from traditional mezzanine-card constraints.

Perhaps the most significant advancement is the ability to plug any QMC card into any QMC carrier without concerns about I/O routing, cooling method, or stacking-height compatibility. This universal approach eliminates the complex matching requirements for system designers with current mezzanine-card standards, which dictate specific cards that must be carefully paired with their carriers.

SBC designers can now focus more intensively on their core competencies, as VITA 93 (QMC) enables simplified I/O mapping by eliminating the need for complex routing schemes. Other advantages include support for multiple I/O functions on the same carrier and reduced design constraints that enable more specialized implementations.

Especially in SWaP applications where space is very limited, the variable stacking height concept with four defined heights (9 mm, 11 mm, 14 mm, and 16 mm, defined by the connector used on the carrier card) enables designers to integrate maximum functionality in limited space. For example, for VPX 1-inch or 1.2-inch carriers, an increased stacking height maximizes the component envelope available on the carrier.

The VITA 93 (QMC) standard supports multiple QMCs on a single carrier, offering advantages over XMC solutions that are typically limited to one or two functions per slot. This flexibility enables SBC designers to support diverse I/O requirements without compromising carrier design. Multiple functions can also be implemented without additional carrier complexity, while scalability is done easily by adding or changing QMC configurations.

In the VITA 93 (QMC) group there were more than 40 different companies participating in the standard's development, many of them SBC vendors. "We expect more and more SBC vendors to offer QMC slots on their future SBC designs, benefiting from the advantages of this new standard," says VITA's Holman.

The highly modular, flexible, and scalable QMC architecture will bring the additional benefit of reduced development costs and minimal time-to-market for system designers, as highly diverse customer requirements can be met with integrated QMC cards.

VITA 93 (QMC) represents a groundbreaking advancement in mezzanine-card technology, offering unmatched modularity, flexibility, scalability, and reliability. With its well-thought-out cooling concept, universal compatibility, and robust design, it sets a new standard for embedded systems across industries.

This article was written by Jan Zimmermann, General Manager at TEWS Technologies and Tim Tews, General Manager at TEWS Technologies (Pineberg, Germany) **www.tews.com**

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Centralized Computing in Next Generation Army Vehicles

In an era where technological advancements are rapid and constant, the U.S. Army will need a more agile and efficient approach to modernizing systems on succeeding generations of Army vehicles. Legacy platforms like Abrams, Stryker, and Bradley vehicles use multiple mission computers tied to individual sensors that often required the addition of "boxes" to accommodate new capabilities, which could take years to deploy and drove sustainment costs up due to vendor lock. In addition, this antiquated approach doesn't leverage data to converge effects across the formation in a multi-domain environment. Centralized, common computing as detailed in GCIA would help solve this problem, potentially linking all major subsystems and providing higher-speed processing to assess large datasets in real time with AI and ML algorithms. By using a common, open architecture computer, the Army will be able to rapidly integrate new capabilities inside one box, versus adding multiple boxes. This pivotal shift would address SWaP concerns because common hardware like antennas and amplifiers could be shared, and cabling would be reduced. It would also simplify sustainment, logistics, and supply chain efforts.

Common computing connected to all the sensors will allow software to share and manage all sensor information to improve

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the Army's percentage of combat readiness. This architecture would consolidate all system health reports and predict failures in advance, enabling commanders and technicians to rapidly assess the health of their fleets and significantly reduce maintenance costs by performing timely repairs. Better informed commanders will also be able to plan operations in advance and synchronize air, land, sea, space, and cyber capabilities to succeed on the multi-domain battlefield. A partnership of multiple software and hardware companies is necessary to make common computing a reality. This would reduce risk, speed development, and ensure new capabilities get to the field faster. Software partners will assure new applications safely and effectively work on the platform and could take advantage of existing software capabilities to reduce costs. Ideally, once an open standard framework is established, it will be easier and faster for software developers to create applications.

The subsystem integrator, on the other hand, would ensure design packages, software, and integration of boards work correctly. Since hardware can easily become the bottleneck in technology upgrades, discussing capability requirements for the next 10 years will allow hardware designers to plan and start development sooner.

Safety

In the past, Army vehicle hardware was primarily designed to ISO 26262 and MIL-STD-882E safety standards. However, DO-254 and DO-178C may be better suited for AI-driven vehicles of the future. The liability of future military autonomous vehicles is similar to tactical drones in the sky. Unlike commercial automobiles, a military vehicle could have automatic weapon systems and autopilot engaged at the same time. Like a drone, weapons misfiring and navigation going awry could lead to loss of assets and casualties. These vehicles will also rely heavily on onboard systems to operate independently, increasing the chances of technical failures. Certifying at the platform, autonomous vehicle level would reduce the possibility of downtime due to failures and subsequent maintenance costs. By using systems designed to DO-254 and DO-178C, military developers can significantly minimize risk and ensure the vehicle can operate reliably without intervention while guaranteeing the safety of its occupants.

Anti-Tamper and Encryption Technologies

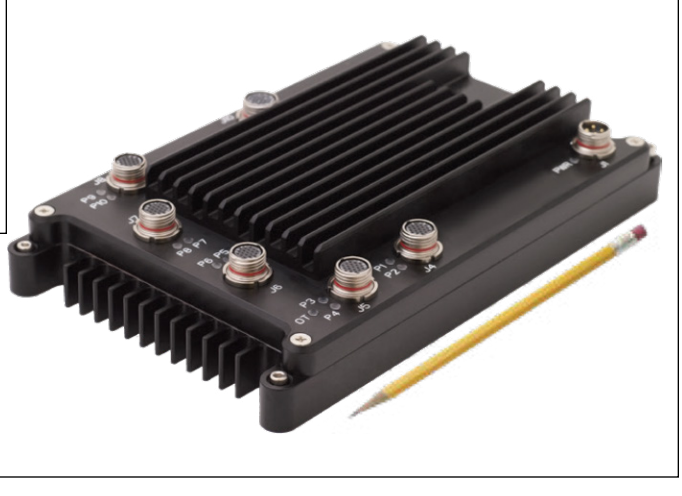
As vehicles become more connected, they are increasingly reliant on software and data connectivity that is vulnerable to cyberattacks. The need to protect information and systems from unauthorized access, modification, or reverse engineering grows exponentially as more and more sensitive and mission-critical data is generated from and stored on manned, unmanned, and autonomous vehicles. Anti-tamper security uses a set of measures and technologies to prevent malicious actors from tampering with or exploiting critical components, software, or data that compromises the integrity, confidentiality, or availability of a protected system. For next-generation Army vehicles and autonomous vehicles, anti-tamper security becomes imperative for several reasons: protection of classified information, preventing unauthorized modifications, safeguarding intellectual property, mitigating cybersecurity risks, and ensuring operational reliability. Army vehicles and autonomous vehicles are deployed in extremely challenging environments, including combat zones or remote areas, and often carry classified mission plans, communication protocols, or sensitive sensor data. Anti-tamper measures ensure that unauthorized individuals cannot access or modify this information, safeguarding both in-field personnel and national security interests. Anti-tamper security mechanisms also detect and prevent unsanctioned modifications to vehicle hardware, software, or firmware intended to compromise its operation.

The advanced technologies and systems that deliver battlespace competitive advantages often contain intellectual property (IP) developed through significant investment of resources. The result of reverse engineering and replication of IP housed within vehicles can be just as destructive as the continuous cybersecurity threats that look to gain control over vehicles remotely, disrupt their communication systems, or manipulate their sensor data. Anti-tamper security measures, including secure communication protocols, encryption, and intrusion detection systems, help mitigate these risks and secure vehicles against such threats and ensure the trustworthiness, safety, and resilience of these vehicles in demanding and hostile environments.

Ruggedization

The next generation of Army vehicles must be tougher and more resilient than their predecessors to meet modern warfare demands. Sensors and electronics will be a vital part of these vehicles, requiring them to be ruggedized to remain operational in extreme combat situations and harsh environments.

Left: Mercury Systems mission computers use the latest commercial technology to process data in near-real time from a variety of sensors. (Image: Mercury Systems)



Right: Network switching provides the backbone for ground vehicle modernization to connect sensors and subsystems. Mercury's NanoSWITCH™ securely enables the transmission of vital data across all network-connected communications devices onboard ground, air, and sea platforms for situational awareness and real-time decisions. Mercury is working to provide integrated cybersecurity capabilities that will enable the switch to operate as an ethernet 'watchdog' to alert operators of malicious activity during standard operations or remote software updates. (Image: Mercury Systems)

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Mercury's LRU1 AMCS mission computer enables seamless integration of newer, more advanced technology across all aircraft. It is an open architecture, software-defined mission computer that will support multiple applications through a converged architecture. It is designed to support the Army's 15-year roadmap and Future Vertical Lift (FVL) program without needing systems upgrades. (Image: Mercury Systems)

Since this article discusses embedded computing architecture for next generation Army vehicles, check out this video of one such vehicle. In July 2024, the Iowa Army National Guard demonstrated their new Squad Multipurpose Equipment Transport (SMET) vehicle's ability to autonomously carry heavy equipment. The vehicle shows the type of functionality embedded computing systems could be enabling in next generation Army vehicles. (Video: Courtesy of the Defense Visual Information Distribution Service)

Advanced navigation and sensor systems must work despite shock and vibration caused by transportation, operation, or drops as well as both high and low temperatures. Onboard computers that control everything from weapon systems to vehicle diagnostics must be designed to endure moisture and physical impacts, preventing deficits in crucial functionality. Systems must also operate at different atmospheric pressures that may be encountered during mountainous terrains.

Components, connectors, and seals must be properly chosen to withstand corrosion caused by rain, saltwater, and humidity. Special filters may be designed-in to mitigate the risk of dust, sand, and fine particles clogging and damaging critical components. Combat zones may also contain toxins such as radiation, open-air burn pits, diesel fumes, and oil-well fires and key equipment cannot fail when exposed to these hazards. Finally, to guarantee reliable communication and operation within a battlefield environment, electronics must operate without interference from external electromagnetic sources or disrupt other nearby electronic devices. Ruggedization reduces the likelihood of expensive repairs or replacements due to environmental damage.

Radar Jamming and Spoofing

Reliable communications are paramount for the Army, requiring radios, GPS units, and data links that are hardened against environmental stresses and electromagnetic interference. Given that autonomous vehicles rely heavily on electronic systems for navigation, communication, and decision-making, they become prime targets for electronic warfare attacks. Electronic systems in autonomous vehicles emit signals that can be detected by enemy radar, making them easy to detect and track. EW can disrupt data streams to render these vehicles ineffective or even turn them into liabilities. Furthermore, advanced radar systems can adjust their frequencies to counteract stealth technologies used by autonomous vehicles, making them vulnerable to detection. Microwave components such as transceivers used for communications and expanded radar (8–12 GHz) can identify, track, and respond to a variety of threats and quickly switch frequencies to maintain communication integrity. Transceivers equipped with advanced digital signal processing (DSP) capabilities can filter out interference, enhance signal quality, and ensure accurate data transmission in the battlefield.

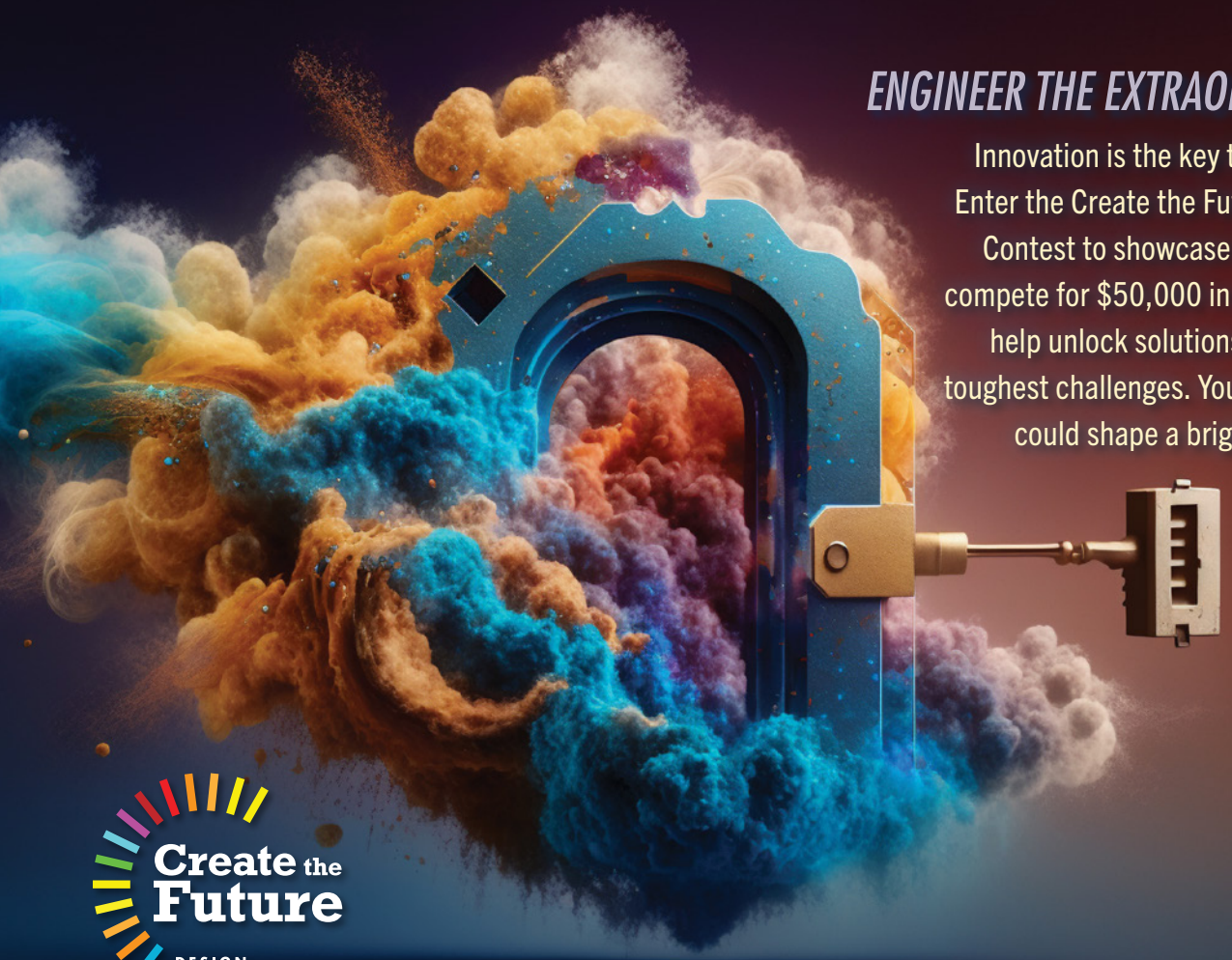
Digitizers will need to digitize output and process it from the microwave transceivers quickly for immediate threat detection and response. High-resolution digitizers ensure the accurate capture of signal data used for identifying subtle EW and radar threats. These same components could also be used to coordinate in-theater attributes used to relay communications in different areas or emit electromagnetic pulses or spoofs to confuse other radars. Due to space restrictions, it will be important to buy equipment capable of running multiple applications, which will also cut logistical and sustainment costs due to common part numbers.

Moving Forward

As we move towards an era of autonomous vehicle warfare, technology will need to remain a top priority to ensure mission success and the safety and security of military personnel and civilians alike. Technology will allow the Army to take advantage of AI and ML to understand, visualize, decide, and direct faster than our adversaries. Now is the time to innovate and invest in the next generation of vehicles.

This article was written by Shaza Khan, Senior Product Marketing Manager and Eric Gans, Director of Business Development, Mercury Systems (Andover, MA). **For more information, visit www.mrcy.com.**

YOUR IDEA COULD UNLOCK THE FUTURE



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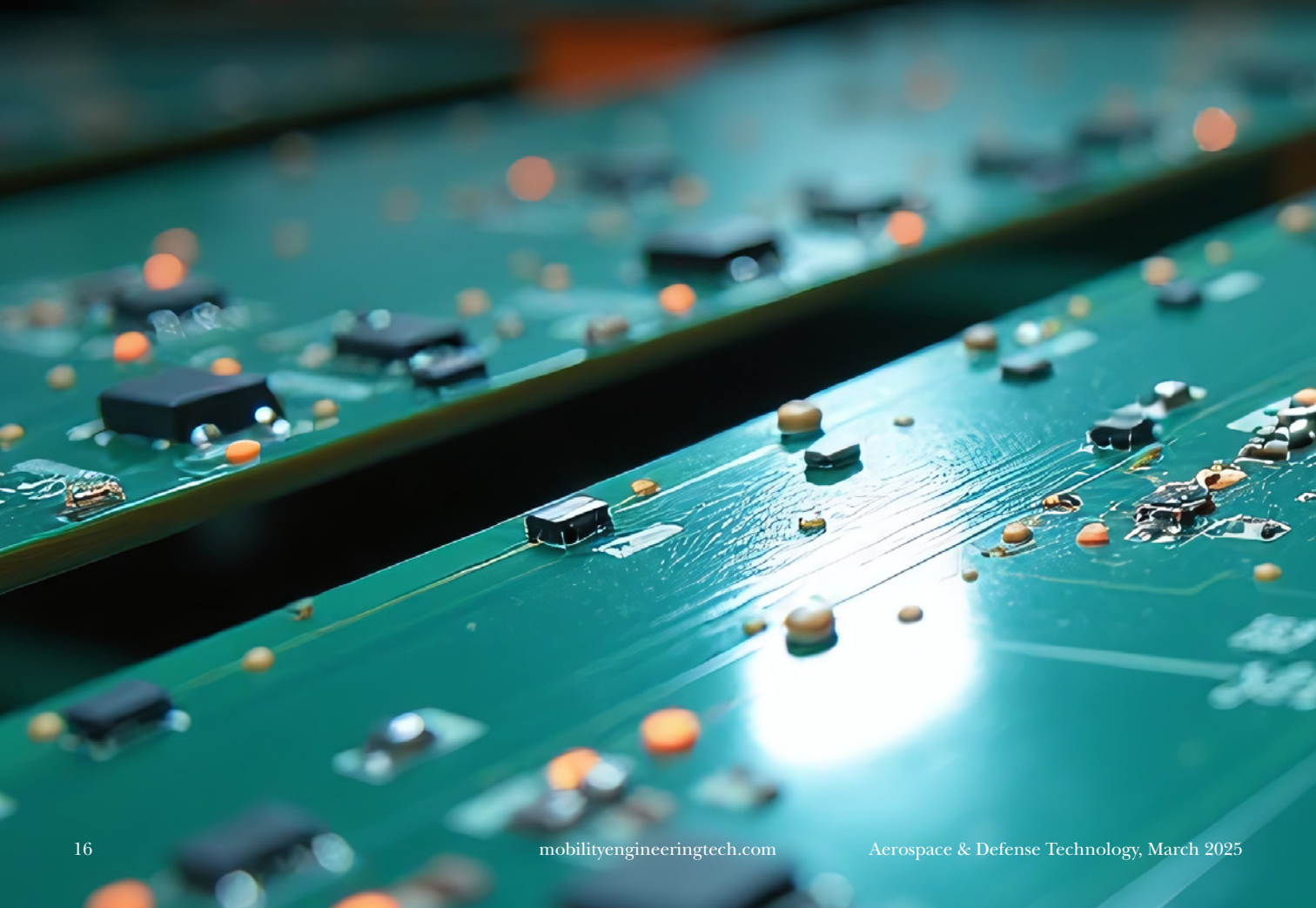
Affordable Mass: *Embracing a New Strategy for Advancing Defense Capabilities*

Affordable mass refers to the ability to rapidly produce large quantities of effective, cost-efficient munitions and systems. It's not about cutting corners but about optimizing every facet of the production process, from design to deployment. The challenge goes beyond strategic methods of design and manufacturing — and must feature industrywide acceptance of affordability as a means of adding capacity, survivability, and efficacy to a new generation of munitions.

The Department of Defense (DoD) is faced with preparing for potential confrontations with peer or near-peer adversaries. Unlike conflicts of the past, where U.S. forces may have faced regional militias with limited air defense capabilities, today's enemy is armed with integrated air defense systems (IADS) capable of countering non-stealth aircraft and outdated weapons. While advanced 5th generation F-35 fighters and B-21 stealth bombers can penetrate these modern air defenses, the Air Force must also develop an inventory of mid-range, stand-in precision-guided munitions (PGMs) designed for contested environments. This fully capitalizes on stealth capabilities and delivers critical battlefield effects on which commanders rely. The ideal inventory of PGMs must offer the capacity, survivability, and effectiveness necessary to ensure that even the most advanced aircraft does not fall short in future conflicts.



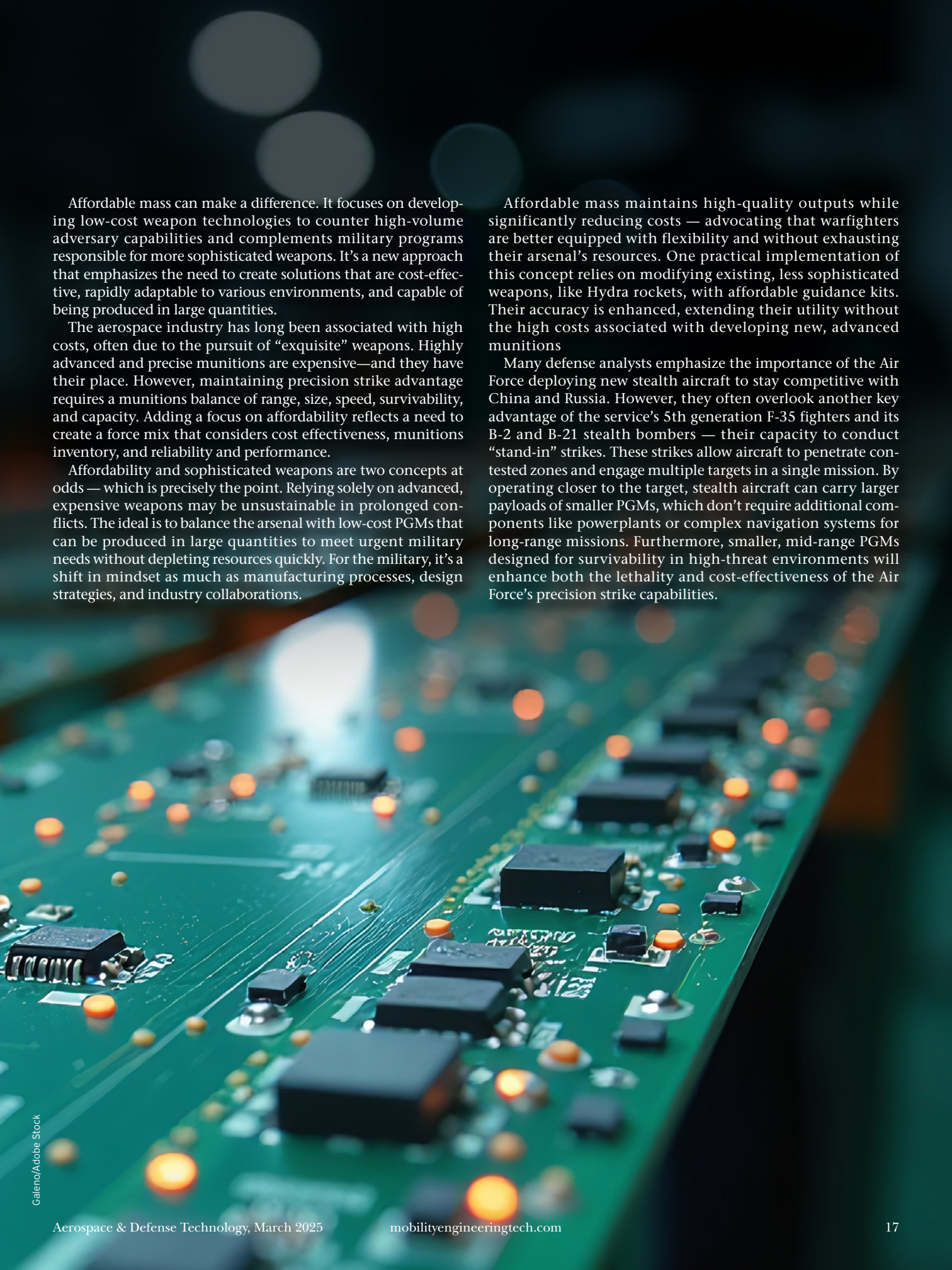
Affordable mass can make a difference. It focuses on developing low-cost weapon technologies to counter high-volume adversary capabilities and complements military programs responsible for more sophisticated weapons. It's a new approach that emphasizes the need to create solutions that are cost-effective, rapidly adaptable to various environments, and capable of being produced in large quantities.

The aerospace industry has long been associated with high costs, often due to the pursuit of "exquisite" weapons. Highly advanced and precise munitions are expensive—and they have their place. However, maintaining precision strike advantage requires a munitions balance of range, size, speed, survivability, and capacity. Adding a focus on affordability reflects a need to create a force mix that considers cost effectiveness, munitions inventory, and reliability and performance.

Affordability and sophisticated weapons are two concepts at odds — which is precisely the point. Relying solely on advanced, expensive weapons may be unsustainable in prolonged conflicts. The ideal is to balance the arsenal with low-cost PGMs that can be produced in large quantities to meet urgent military needs without depleting resources quickly. For the military, it's a shift in mindset as much as manufacturing processes, design strategies, and industry collaborations.

Affordable mass maintains high-quality outputs while significantly reducing costs — advocating that warfighters are better equipped with flexibility and without exhausting their arsenal's resources. One practical implementation of this concept relies on modifying existing, less sophisticated weapons, like Hydra rockets, with affordable guidance kits. Their accuracy is enhanced, extending their utility without the high costs associated with developing new, advanced munitions

Many defense analysts emphasize the importance of the Air Force deploying new stealth aircraft to stay competitive with China and Russia. However, they often overlook another key advantage of the service's 5th generation F-35 fighters and its B-2 and B-21 stealth bombers — their capacity to conduct "stand-in" strikes. These strikes allow aircraft to penetrate contested zones and engage multiple targets in a single mission. By operating closer to the target, stealth aircraft can carry larger payloads of smaller PGMs, which don't require additional components like powerplants or complex navigation systems for long-range missions. Furthermore, smaller, mid-range PGMs designed for survivability in high-threat environments will enhance both the lethality and cost-effectiveness of the Air Force's precision strike capabilities.



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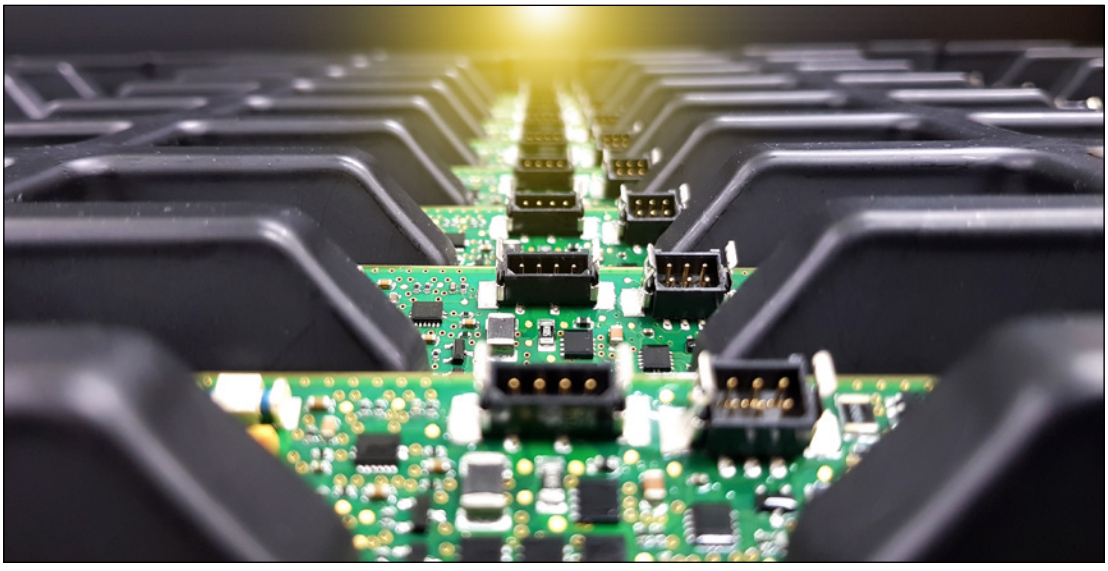


Using standardized parts and components across different projects or models illustrates how these conflicting demands can be balanced for cost-effectiveness. Marotta Controls provides an example, achieving modularity in its control actuation systems (CAS) by standardizing on key system components that can be leveraged across programs. By using a circuit card assembly that has been proven successful in one of its high-volume CAS programs and incorporating it (with minor adjustments to the firmware) into another production, the company has decreased design time and created an economy of scale in purchasing circuit card assemblies. (Image: iStock)

For affordable mass to become a greater reality, the industry must move away from the pursuit of perfection at any cost. Instead, industry leaders should focus on creating "good enough" solutions that meet mission requirements without excessive costs. Such a shift requires a cultural change within many organizations, with designers, engineers, and executives learning to value cost-effective solutions as highly as cutting-edge technologies.

With this shift in mindset, real-world actions can more effectively follow. It's a critical step in aerospace companies becoming more willing to adopt flexible design practices and brace for rapid adaptation to new requirements and environments.

For example, flexible design is essential to achieving affordable mass. As aerospace systems become more easily adaptable to different requirements and environments, changes in operational directives won't necessarily drive completely new designs. Overall mass and cost can also be reduced with the development and use of advanced materials such as composites, alloys, and lightweight metals that offer superior strength-to-weight ratios and durability.

Manufacturing processes must also be more accommodating, featuring the ability to quickly switch between different production lines or products. This agility is crucial for responding to changing demands in a timely manner and should be a defining characteristic of aerospace manufacturing partnerships.

Supply chain operations must mirror the same kind of collaboration. By working closely with suppliers, manufacturers can ensure that materials and components are available when needed and that production processes are as effective as possible. By sharing information and aligning goals within each level of the supply chain, companies can further reduce lead times and improve overall efficiency.

Enhancing the supply chain reduces lead times, improves supplier relationships, and ensures the delivery of materials and components. Achieving affordable mass requires working closely with all levels of the supply chain to production processes that are aligned and optimized for cost efficiency. Collaborative efforts can lead to innovations that reduce costs while maintaining quality and performance. For example, engaging with suppliers early in the design process can confirm that materials and components are readily available and cost-effective. Partnering with other companies, research institutions, and government agencies allows the sharing of costs, expertise, and resources.

These same cooperative values can also support aerospace manufacturers in balancing standardization with customization. While customization is often required to meet specific mission requirements, introducing standardization wherever possible can reduce costs and streamline production. Reducing the need for custom parts, simplifying inventory management, and enabling bulk purchasing are all tenets of affordable mass and contribute to cost savings.

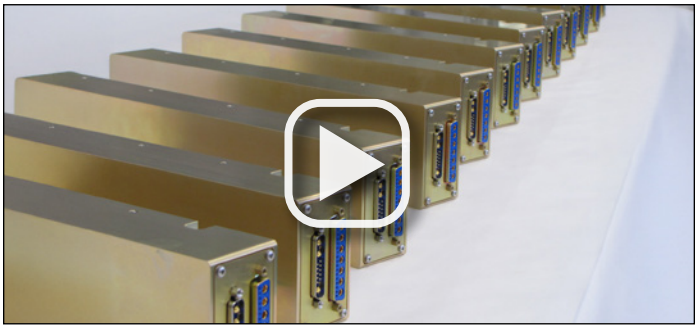
In a practical example, affordable mass can be advanced by identifying existing systems in production where specific components for other systems can be leveraged for advantages in both cost and performance. The shifting aerospace culture must recognize the need to achieve minimum viability for our products, including only the features essential to their design and purpose. Yes, we do have the exquisite products — but we must understand when those are and are not needed and be able to pivot to lower-cost system solutions appropriate for the mission.

Adapting strategies and resources to drive affordable mass systems today is an important step for the future. Clearly, all the factors needed to achieve affordable mass point to the need for a new level of innovation. Aerospace firms should antici-

pate the need for continuous investment in research and development to further drive innovation and advance new technologies that can reduce costs and improve performance. This includes workforce investments as well, such as providing employee training and development opportunities to build the skills that better support affordable mass ideals and strategies across the aerospace enterprise.

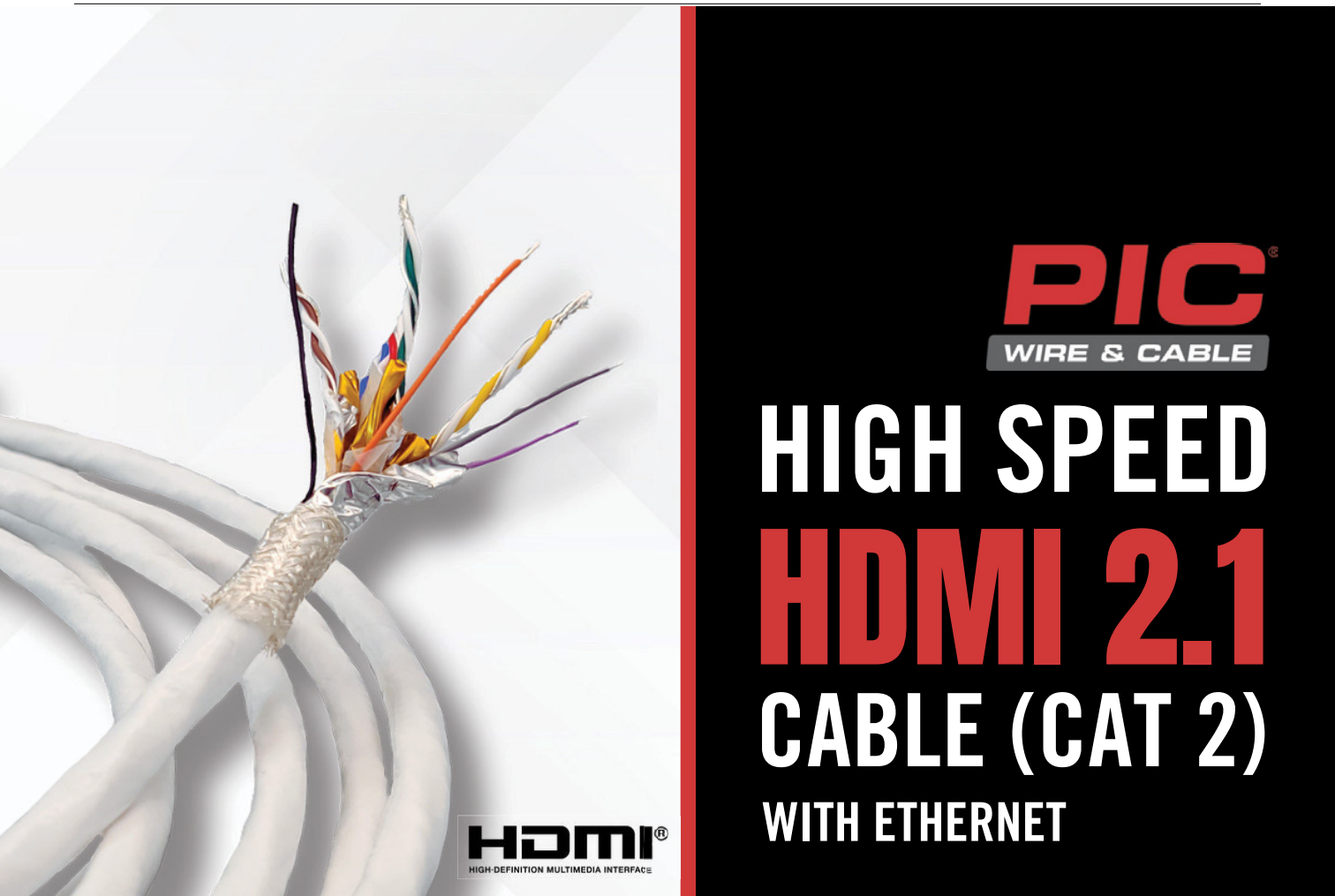
As global conflicts and geopolitical tensions steadily rise, the demand for rapid deployment and sustained military capacity increases in step. Smart choices are vital and must be grounded in an urgent rethinking of traditional aerospace manufacturing and supply chain management approaches. Maximizing combat power relies on a cost-effective mix of capabilities such as PGMs that leverage advanced 5th generation fighters and stealth bombers as key advantages.

The demands of the modern battlefield require aerospace leaders to broadly embrace the concept of affordable mass. This cultural shift means adopting a mindset focused on cost efficiency, flexibility, and new technologies and partnerships. This is not optional — the Air Force's cutting-edge aircraft can only be as effective as the PGM inventory supporting them, which must have the capacity, durability, and impact necessary to secure victory in future conflicts. To best support the warfighter and enable a force fit for the future, the industry can and must deliver the capabilities needed to ensure military readiness and resiliency for any challenge.



Power supplies are shown here in volume production, a primary characteristic of affordable mass goals which focus on the ability to rapidly produce large quantities of effective, cost-efficient munitions and systems. Marotta discusses its affordable mass capabilities in this video. (Image: iStock)

This article was written by Adit Girdhari, Vice President of Business Development, Marotta Controls (Montville, NJ). **For more information, visit www.marotta.com.**



Next Level Rugged Fiber Optic Interconnects: A New Era of High-Speed Data Transmission in Defense

State-of-the-art fighter aircraft have a large number of support systems that operate in multiple areas. These systems are continuously optimized to achieve maximum efficiency and performance. Countless sensors monitor the environment and generate important data that helps to understand the areas overflown. But even in life-threatening combat situations, target acquisition systems support pilots and provide additional information that can be decisive with the help of augmented reality (AR) and artificial intelligence (AI). Military aviation is an arena with great potential for the use of technical aids that have transformed the original fighter aircraft into a technological masterpiece.

In addition to the high level of complexity, the upcoming generation change from fifth- to sixth-generation fighter jets poses major challenges for component suppliers and accelerates the pace of technological competition. A military fighter jet is already an extremely demanding environment for technical equipment.

The Harsh Environmental Challenges of Military Aviation

Compared to civilian applications, there are special requirements for the performance and robustness of subsystems and their connections that are used in aerospace and defense platforms. They must be reliable and withstand high mechanical stresses such as shock and vibration. Eavesdropping security and resistance to jamming signals also play a key role. Environmental influences such as extreme temperature fluctuations or contamination with aerosols and liquids are ever-present and must be considered as a preventive measure.

As the number of subsystems increases, so does the amount of data to be transmitted. Conventional copper-based cabling technology does not provide the required data rates and would be too heavy at sufficient capacity. By using fiber optic systems, these problems can be avoided and more secure data streams can be guaranteed.

The collected data is usually processed by mission computers. These are embedded systems that are customized to meet the

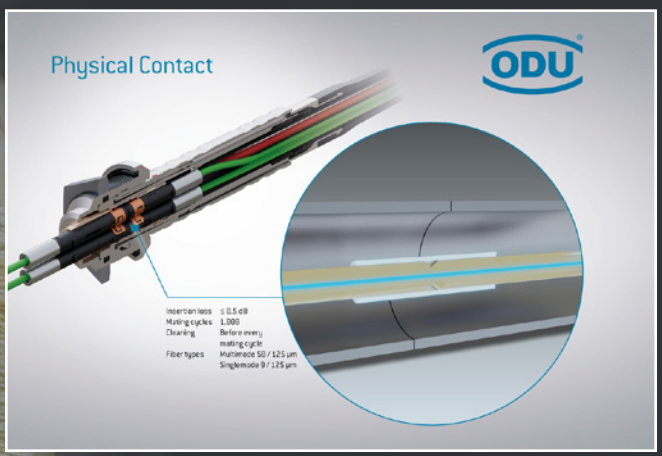
Background Image: Yuri Bartenev/Adobe Stock

specific requirements of the flight platforms and integrated subsystems. Their structure is based on defined standards to ensure uniformity, interoperability and compatibility with subsystems.

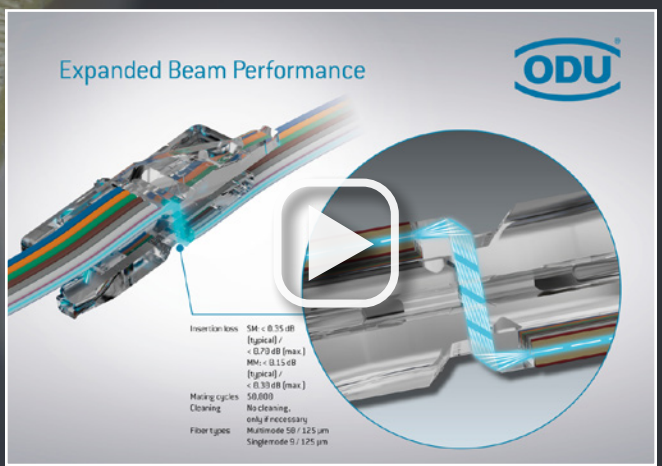
The required modules inside are connected via direct backplane interfaces and can be exchanged as needed. Peripheral systems, on the other hand, are connected via I/O interfaces. These are subject to much higher levels of stress in daily use. In order to use the optical signals from the fiber, the cables are connected to the PCBs via optical transceivers.

Current Solutions and Their Problems

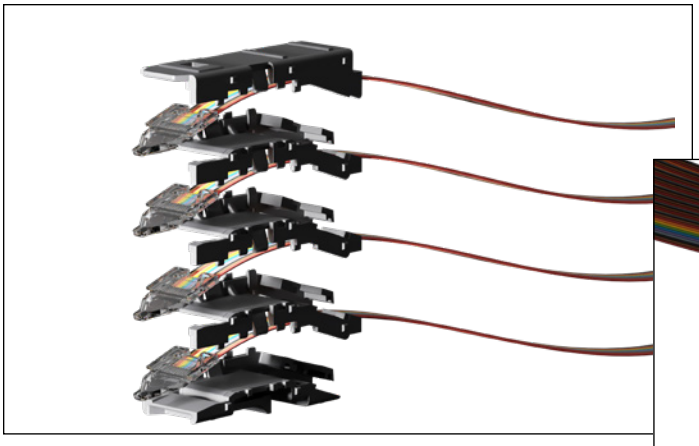
Physical Contact (PC) connectors have become well established in the aerospace and defense market. The two fiber ends are polished and precisely brought together using special tools. This physical contact allows the light signal to be transmitted from one fiber to the next. PC connections are characterized by


Physical Contact
ODU
Insertion loss ≤ 0.5 dB
Mating cycles 1,000
Cleaning Before every mating cycle
Fiber types Multimode 50 / 125 µm
Singlemode 9 / 125 µm

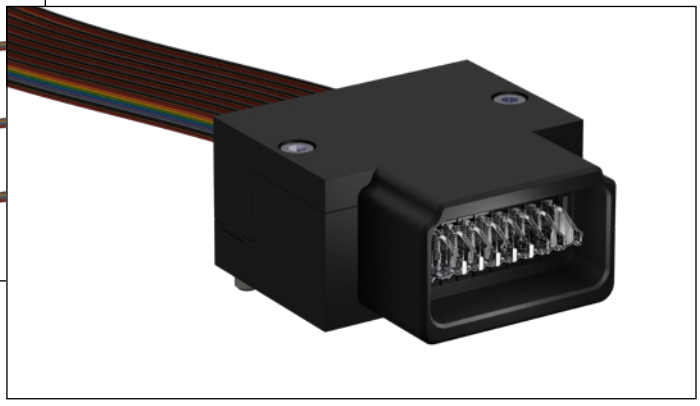
This image shows the light path within a physical contact connection that can be used within a fighter jet, or other aerospace or defense platform. (Image: ODU GmbH & Co. KG)


Expanded Beam Performance
ODU
Insertion loss SM: < 0.35 dB (typical) / < 0.70 dB (max.) MM: < 0.15 dB (typical) / < 0.30 dB (max.)
Mating cycles 50,000
Cleaning No cleaning, only if necessary
Fiber types Multimode 50 / 125 µm
Singlemode 9 / 125 µm

Light path crossing through a mated pair of expanded beam performance ferrules. Learn more about the capabilities of ODU's expanded beam performance ferrules in this video. (Image: ODU GmbH & Co. KG)



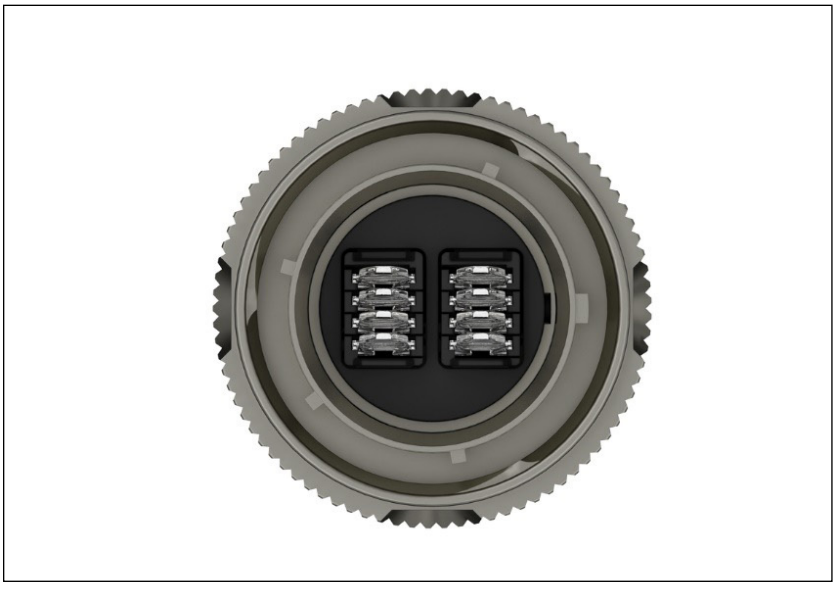
Left: Four Expanded Beam Performance ferrules stacked on top of each other for maximum packing density. (Image: ODU GmbH & Co. KG)



Right: This is a backplane connector developed in alignment with the upcoming VITA 96.1 standard. (Image: ODU GmbH & Co. KG)

very good transmission properties. Small dust particles or coarser contaminants can quickly scratch the polished surfaces and degrade the transmission properties. Direct physical contact also causes slight wear, limiting connector life to a few hundred mating cycles.

To delay connector failure as long as possible and to ensure reliable, error-free data transmission, the interfaces are manually cleaned after each mating cycle. Modern military aircraft have many of these connections and typically require maintenance before and after each mission. This results in an enormous amount of maintenance and cleaning, as well as a short life span for the contacts.



The Interface of a SHS 17 MIL-DTL-38999, Series III plug with 8 Expanded Beam Performance ferrules, following the upcoming VITA 95 standard. (Image: ODU GmbH & Co. KG)

Despite this, the technology has become the market standard. The filigree standalone contacts are available with an extremely small diameter of 1.25 mm. Special Ferrules like MTs drive this effect even further and provide an extremely high packing density. The standardized MT ferrules allow up to 24 fibers to be bundled together for fast connection and disconnection of data cables. Specific standards exist under VITA 66, VITA 87 and VITA 89 that define the dimensions and quality requirements for those connectors.

Alternatives to the Standard

Expanded beam technology is a possible alternative to PC solutions. A lens expands the light beam at the end of the fiber before it passes through a short air gap. A second lens focuses the light signal and transmits it into the connected fiber.

By dispersing the light signal, the connections are less susceptible to signal interference caused by contamination or mechanical influences. With up to 100,000 mating cycles, Expanded Beam technology offers a robust and durable alternative that requires less maintenance and is significantly more efficient than PC solutions.

The downside is that lens-based signal transmission cannot match the outstanding performance of PC connectors. In particular, the higher insertion loss reduces the technology's potential for military aerospace applications. Another drawback is the physical size of the connector. Due to the larger diameter, it is not possible to achieve such a dense arrangement of multiple contact elements, which means that interconnect solutions for large number of optical fibers would take up a lot of space in the final application.

Best of Both Worlds - Expanded Beam Performance

Expanded Beam Performance technology combines the advantages of PC connectivity with the robustness of lens-based data transmission. The result is connectors that are highly resistant to wear, contamination and mechanical stress, while providing excellent transmission characteristics.

For example, typical insertion loss remains low at <0.15 dB for multimode and <0.35 dB for singlemode, ensuring minimal data degradation. Return loss values are equally impressive, exceeding 45 dB (multimode) and 60 dB (singlemode).

The innovative design of the Expanded Beam Performance Ferrule allows 12 optical fibers to be connected without direct end face contact. This means that up to 50,000 mating cycles can be achieved with no wear and no loss of transmission characteristics. Under normal circumstances, there is no need to clean the joint, as is the case with PC connectors. This makes the technology the perfect basis for data transmission in demanding, harsh environments.

The cassette principle allows multiple ferrules to be stacked in a very small space, making the connection solutions suitable for systems with large amounts of data. The end contact elements are available in different dimensions, depending on the requirements and available space.

VITA 96 Backplane Connection

The backplane connector allows direct connection of modules and mission computers. Its high number of mating cycles and low maintenance requirements make it particularly suitable for applications that require regular module replacement over long periods of time.

The ODU BACKPLANE connection solutions are available in three different versions for the connection of up to 96 optical fibers according to the future standards VITA 96.1, VITA 96.4 and VITA 96.5. Since they fit into the same apertures, they are a low-maintenance alternative to VITA 66 solutions.

Robust and Low-Maintenance I/O Interfaces

I/O interfaces in the form of circular connectors are commonly used to connect peripheral systems. They are characterized by their robust design, intuitive handling and reliable locking mechanisms. Standardized solutions have been available for some time in the form of VITA 87 and VITA 89, which standardize fiber optic connections with a large number of contact elements. However, even these solutions do not offer sufficient durability and require costly maintenance.

The total cost of ownership can be reduced by using low-maintenance alternatives. Applications experience less downtime and are used more efficiently.

Connectors based on the future VITA 95 standard integrate the robust Expanded Beam Performance technology in 38999, Series III housings and are the ideal alternative to conventional solutions. With ODU TACTICS, the first solutions based on this principle are now available on the market. With the AMC Series T, the German manufacturer offers a connection solution in its own design - even smaller, even lighter, but just as robust as the familiar 38999 connections.

Until now, there has been no optimal solution for transmitting large amounts of data in demanding applications such as military aviation. Expanded Beam Performance technology is an important step forward. It provides systems with excellent transmission characteristics and low maintenance requirements. With a long service life, the products are a more cost-effective alternative to current links and reduce application downtime.

This article was written by Thomas Mittermeier, Strategic Business Development Manager, ODU Group (Camarillo, CA). **For more information, visit www.odu-connectors.com.**

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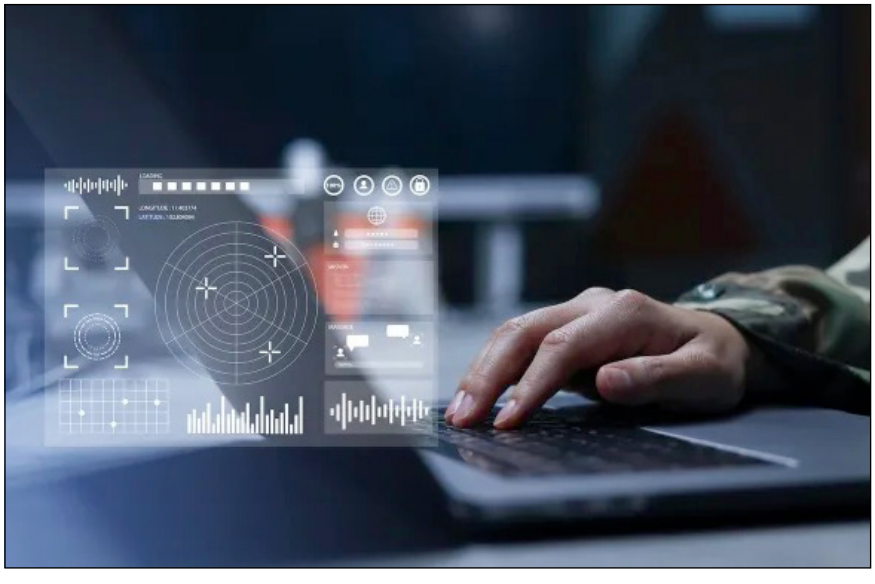
5 Startups Developing AI for Defense Applications

Artificial intelligence (AI) and machine learning (ML) are being adopted and deployed across the global aerospace and defense industry in a wide variety of software and hardware-defined applications right now. Here are five startups developing new and novel AI and ML technologies for aerospace and defense applications. This list is not intended to be in a ranking order.

Background Image: KP/Adobe Stock

01 EdgeRunner AI

Year Founded: 2024
Location: Seattle, WA
CEO: Tyler Saltsman



EdgeRunner AI is focused on enabling the concept of "Generative AI at the Edge," or the use of air-gapped, on-device AI agents for military and enterprise applications. The startup describes its mission as developing small, task-specific Ultra-Efficient Language Models (UELMs) that operate without needing internet access, and providing an industrial type of Generative AI that can run locally on any device or hardware. "Specifically developed for the military, this technology offers both defense and enterprise users a hyper-personalized assistant powered by AI agents that functions independently of internet connectivity," the company notes on its website. EdgeRunner has already established development partnerships with the Department of Defense (DoD). The startup's focus on enabling Generative AI that does not require internet connectivity could prove to be a game-changer for defense units that do not want to run models or algorithms on devices connected to the web. Their engineers are currently involved in ongoing collaboration with the Space Systems Command on the use of their on-device AI agents for real-time satellite characterization and threat assessment of images.

For more information, visit here.

02 Anduril Industries

Year Founded: 2017
Location: Orange County, CA
CEO: Palmer Luckey

Anduril Industries has been gaining major traction and major DoD contracts over the last two years. The startup has developed a unique mix of AI-enabled drones, vehicles and platforms as well as the use of AI and autonomy within its manufacturing process. Their proprietary "Lattice AI" is an AI-enabled software application that takes data from distributed or disparate sensors and edge devices, and merges it into a single integration layer. The U.S. Special Operations Command uses Lattice for countering unmanned aircraft systems in challenging and austere environments. In November 2024, the U.S. Army began testing their GhostX autonomous drone at a military base in Romania. The startup is also currently delivering its Roadrunner-M twin-jet powered autonomous vehicle and Pulsar electronic warfare platform to DoD for air defense capabilities. In February 2025, the Army confirmed Microsoft Corp. and Anduril as the new developers of their Integrated Visual Augmentation System (IVAS) program. By the end of 2025, the startup expects to begin production of its DIVE-XL autonomous underwater vehicles for deliveries to the Australian Navy.

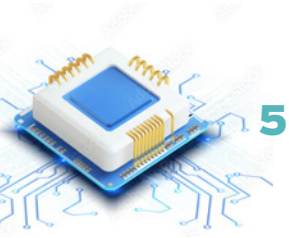
For more information, visit here.

03 DEFCON AI

Year Founded: 2022
Location: McLean, VA
CEO: Yisroel Brumer

DEFCON AI's focus is leveraging AI to build next generation modeling, simulation and analysis (MS&A) tools for military transportation and logistics operations. Their AI-driven software features an intelligent agent that helps warfighters respond and adjust to logistics and supply chain disruptions in contested mobility environments. In August 2024, DEFCON delivered its "ARTIV" MS&A decision-support platform to the Air Force's Air Mobility Command. ARTIV allows planners to test and optimize operational logistics and transportation concepts in advance of crises – such as an attack on an airport or a storm causing severe disruptions at a major port. The cloud-native tool enables planners to train under various real-world scenarios so they can minimize interruptions to ensure the fast mobilization of resources regardless of the operational disruption. Among the notable features of ARTIV is its Resiliency Setting involving an intelligent Red Agent that looks for vulnerabilities in plans that adversaries could exploit, allowing logistics and transportation planners to strategize and optimize responses to potential disruptions.

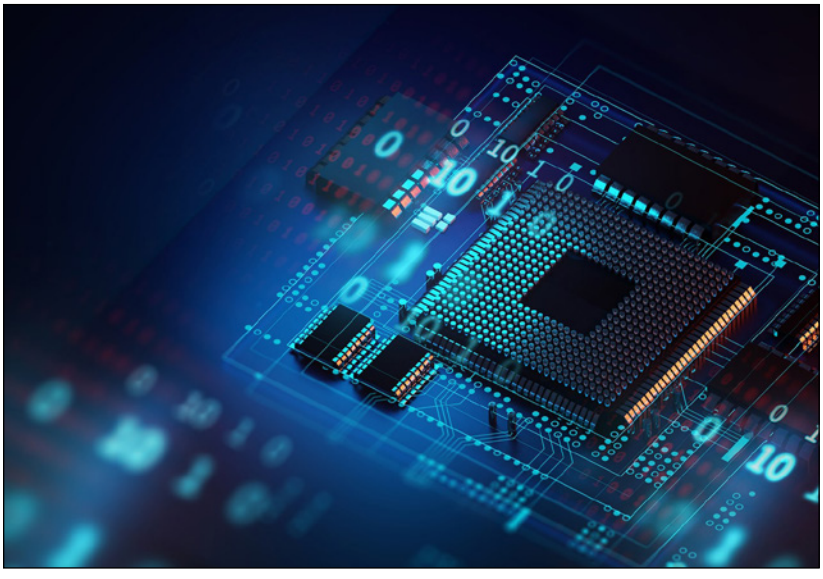
For more information, visit here.



5 Startups Developing AI

04 EnCharge AI

Year Founded: 2022
Location: Santa Clara, CA
CEO: Naveen Verma



EnCharge AI does not exclusively focus on defense applications, however, one research and development project they're currently involved in could help change the way defense-relevant AI workloads are achieved in the future. In March 2024, EnCharge AI announced a partnership with Princeton University and the U.S. Defense Advanced Research Projects Agency (DARPA) towards developing advanced processors capable of running AI models more efficiently than previously thought possible. DARPA'S Optimum Processing Technology Inside Memory Arrays (OPTIMA) program is a $78 million effort to develop fast, power-efficient, and scalable compute-in-memory accelerators that can unlock new possibilities for commercial and defense-relevant AI workloads not achievable with current technology. As part of OPTIMA, DARPA has awarded an $18.6 million grant to a multi-year project proposed by Princeton University and EnCharge AI. The project will explore advancements and end-to-end workload execution of AI applications using the next generation of switched-capacitor analog in-memory computing chips pioneered by Dr. Naveen Verma's lab and commercialized by EnCharge AI.

For more information, visit here.

05 Helsing

Year Founded: 2021
Location: Munich, Germany
CEO: Gundbert Scherf

Helsing is a native software AI startup that has experienced significant expansion in securing European investment and defense contracts since it was established just four years ago. Their core competency is developing AI software and algorithms that can improve battlefield decision-making, process critical information from air and ground defense systems, and improve the performance of drones, fighter jets and other mobile platforms. In a December 2024 white paper, Helsing engineers outlined their approach to software-defined assurance for defense applications and their belief that a new "software-defined defense" era of warfare is emerging globally. Helsing unveiled its HX-2 electrically propelled X-wing strike drone in 2024. In February, Helsing announced it would be producing 6,000 HX-2 strike drones for Ukraine, following a previous order for 4,000 of its HF-1 model strike drones. The startup is also in the process of completing its first "Resilience Factory" facility in southern Germany, which will have an initial monthly production capacity for more than 1,000 HX-2 drones. Niklas Köhler, co-founder of Helsing said: "We have assembled Europe's world-leading manufacturing talent to completely rethink and develop a new generation of mass producible effects," Niklas Köhler, Co-Founder of Helsing said in their February announcement about HX-2 production. "Our Resilience Factories combine software-first design with scalable manufacturing techniques. We solve the hard problems in the software layer, not the electronics. This generates affordable precision mass, deters adversaries, and protects our democracies. HX-2 is just the first of a whole range of products based on this premise."

For more information, visit here.

How Will TSN Ethernet Impact the Future of Embedded Computing for Aerospace and Defense Applications?

Time Sensitive Networking (TSN) Ethernet is a real-time networking capability that is being developed by a growing number of embedded computing companies for the earliest stages of adoption by aerospace and defense manufacturers and their suppliers. According to the Institute of Electrical and Electronics Engineers (IEEE) TSN working group, it is a set of standards that provides deterministic connectivity within IEEE 802-aligned networks.

Nigel Forrester is the Director of Product Strategy for Concurrent Technologies, a UK-based provider of high performance embedded computing solutions for aerospace, defense and many other industries. Check out our interview with Forrester about the potential impact of TSN Ethernet on new and legacy aerospace and defense applications, and how it is being adopted by manufacturers and system integrators below.

***Aerospace & Defense Technology (A&DT):* What is TSN Ethernet?**

Nigel Forrester: It is a set of IEEE standards that improve Ethernet. What do I mean by that? I mean, it meets the needs of real time control systems by allowing deterministic communication over that Ethernet fabric. And by deterministic, I mean highly repeatable from a timescale perspective. And it does that by providing predictable latency and timing accuracy.

It's really about real time communication using an Ethernet fabric. That's what it is. How does it work? It builds on a number of key premises. The first thing is time synchronization. Using existing IEEE protocols like the precision timing protocol, 1588, TSN synchronizes clocks across all the devices on the network. What that does, is it provides a highly accurate com-

Andrey VP/Adobe Stock

TSN Ethernet could be an ideal embedded networking standard for size and weight-constrained technologies such as drones, because it allows for a reduction in the cabling required to establish the network. (Image: Zape/Adobe Stock)

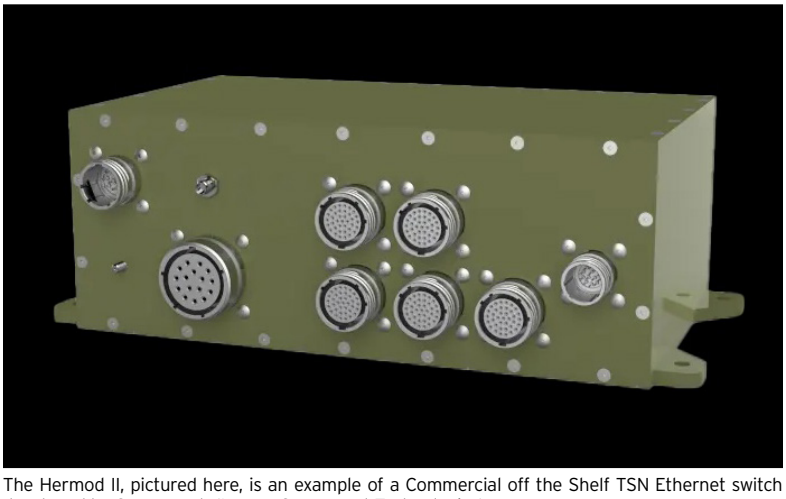
mon reference point using a designated grand master clock. That's really important because if you're going to have time communication, you have to make sure that every device is synchronized to the same time and a very accurate time within that system. That's the first core part of it.

Another one of the really key parts is setting up various quality of service mechanisms. Effectively, these are like priority-based scheduling and traffic shaping, and what they do is they prioritize the time critical data over non-time critical data. That network scheduling enables a mechanism that reserves time slots for the critical data streams.

By reserving time slots, that gives you predictable transmission with minimal latency and jitter, and then the time shaping is there. If you define time windows for the data transmission, the time sensitive networking shaping capability manages the flow of traffic. TSN also uses redundant links and protocols to provide multiple paths for time critical traffic. If one link gets broken, then you have a backup link that you can fall back on.

TSN is not one standard in its own right. It's a bit of a smorgasbord of different standards. For different industries, different elements of TSN are required.

A&DT: **When you look at the types of networking interfaces, protocols and standards featured on in-service military ground vehicles, aircraft, drones and other platforms today, how do those legacy networks compare to what TSN can provide?**



The Hermod II, pictured here, is an example of a Commercial off the Shelf TSN Ethernet switch developed by Concurrent. (Image: Concurrent Technologies)

Forrester: There certainly are lots of legacy networks and protocols in use today. From an airframe perspective, you've got things like MIL-STD-1553 and ARINC 429, and possibly 629. If it's a ground vehicle, you might have CAN Bus or even FlexRay if it's a relatively new vehicle. I think the key here is that those legacy protocols, they've been around for many years. They work really well. There's nothing really that TSN is looking to do better than those legacy protocols. But what it can do is, if you think about, especially in the drone, be it a land, air, or sea drone, they are battery powered and very often they have to run for long periods of time. So size, weight, power, and actually cost, is perhaps the most critical consideration for those types of platforms.

If you can standardize on a single Ethernet network, all your control capability and applications within that platform, that dramatically reduces

the weight and the power required to enable the system. Think of a single Ethernet cable running through the platform rather than multiple 1553 CAN Bus or serial port type cables. In the long term, that really gives you a cost advantage because those legacy interfaces are quite difficult to support.

So it's really more about how you can make the platforms better and more flexible rather than how do you actually make the interfaces run faster or more responsive. A lot of these legacy interfaces, they do a good job, they just are not really fit for purpose in the long term.

***A&DT:* Speaking of the long term, what is the current status of TSN Ethernet within the aerospace and defense industry? Is it already being adopted by manufacturers?**

Forrester: It's starting. Remember that in the aerospace industry, things do tend to have quite long qualification sample cycles. So if you ask me, has Concurrent shipped multiple TSN products? That answer is absolutely. Have we received many RFPs from U.S. and UK companies explicitly calling out TSN as a mandatory requirement for new platforms? Again, absolutely. Do we actually have lots of TSN products deployed today? Well, no, if I'm honest, but it's coming and not only on new platforms. We've actually seen some opportunities to add TSN to existing and legacy platforms during their technology transition cycles.

Those legacy interfaces are not going to go away. The will have to co-exist with TSN in some cases decades. Because if you have a platform with a legacy interface today, it's probably unlikely that you're going to completely rip it all out and start over again.

***A&DT:* If you look out over the next 5-10 years, what type of impact could TSN Ethernet have on the design and form factors of embedded military computing systems and components?**

Forrester: I wholly believe that TSN is going to increase the flexibility of platforms. One thing we've seen in the last few years is a strong desire for a single platform design to be easily reconfigured. So you may have an EW platform today, but you want to extend the capability to add some additional signal intelligence. It's very easy to do that if everything is based around an Ethernet backbone. You don't have to add additional I/O capabilities. The cabling, the look, the feel of the platforms is identical, you're just adding additional protocols, application capability or reconfiguring what you've already got.

The other thing I think that it will really help with is this huge impetus in the western world to improve the responsiveness. How do we get equipment out to our warfighters quicker? The type of adversaries that we are facing, they're quite often using off the shelf commercial equipment. They can bring new things to market quickly. They probably don't last very long. They might not function very well; they have to have the ability to speed the time to market for some of these things. And again,

From our own company perspective, if I go around our software team here, I'm sure lots and lots of them will have the capability to program an Ethernet socket-based application. If I ask, well, how many of you have the capability to do that on 1553, I'm probably going to get a pretty small number of responses.

For more information visit www.concurrent.tech.

Listen to the podcast with Nigel Forrester

A Supercomputer for *Aerospace and Defense Systems Modeling and Simulation*

In February 2024, Cadence launched a new generation of computational fluid dynamics (CFD) with the introduction of the Millennium M1 CFD Supercomputer.

Millennium M1 is a graphics processor unit (GPU)-based hardware system that is also available with no hardware completely in the cloud. Cadence describes it as the industry's first hardware/software (HW/SW) accelerated digital twin solutions for multi physics system design and analysis. Millennium M1 was developed using some of the latest accelerated compute technology available from NVIDIA, such as graphics processing units (GPUs), as well as near-linear scaling and up to 32,000 CPU-core equivalents that allows predictive CFD simulations to run ahead of production testing.

The system's advanced architecture and cutting-edge technology make it a game-changer in the field, providing researchers and engineers with a powerful tool to tackle complex simulations and analyses.

What is a CFD supercomputer, how does it work and what could it provide for engineers and designers of complex aerospace and defense electronics and mechanical systems? Check out some of our Q&A session with Frank Ham, Vice President of Research and Development at Cadence, during his appearance on the Aerospace & Defense Technology podcast to answer these questions and more.

***Aerospace & Defense Technology (A&DT):* What is multi-physics simulation and how is it being used today in the aerospace and defense industry?**

Frank Ham: Multi-physics simulation is essentially the simulation that involves multi, meaning two or more different physics-based modeling approaches, interacting together. So if we restrict the discussion to just CFD, a multi-physics simulation example would be something like fluid flow plus heat transfer.

That would be predicting the heating experienced by a high-speed vehicle, for example, or fluid flow and combustion being used to predict the exit temperature profile of a gas turbine engine. Another example would be fluid structure interaction. In aerospace, this would be used to predict the buffeting boundary at the edge of the flight envelope.

One last example that's kind of fun is actually computing sound. Sound is part of the Navier-Stokes equations, the equations that are solved with CFD.

Nowadays, you can run a simulation of a plane or a drone and actually listen to it and get its noise signature. This early stage virtual prototyping is very valuable when you're trying to make vehicles safer, more efficient, and quieter.

Background image: AddMeshCube/Adobe Stock

Cadence describes its Millennium M1 Supercomputer as "the industry's first hardware/software (HW/SW) accelerated digital twin solution for multiphysics system design and analysis." (Image: Cadence)

Millenium M1 Supercomputer

A&DT: **What are some of the main software and hardware components that make Millenium M1 a CFD "supercomputer" as Cadence describes it?**

Ham: One of the longstanding challenges with multi-physics simulation and particularly multi-physics CFD is that it's computationally costly. It's traditionally required large supercomputers with many thousands of CPU cores and in some cases many days to complete even a single simulation.

But modern GPUs, so that is graphics processing units, and the accelerated computing paradigm are changing all of this. Using GPUs and software that is specially designed to run on GPUs, multi-physics CFD can be sped up by at least an order of magnitude or more. And with much lower power consumption as well.

This can turn a week of simulation into a day, or a day into a couple of hours. This is what's transforming the impact of multi-physics CFD on design in many industries. For a company that's currently using more traditional approaches in simulation, I would say there are two big challenges with realizing the benefits of this accelerated computing.

The first is of course, that the software architecture has to change. It must be specially designed, to be resident on the GPU, to run with the GPUs. The Fidelity Large Eddy Simulation Solver was one of the first CFD solvers to actually take this leap many years ago.

The second challenge for a company would be to get consistent access to cost-effective GPU hardware, specifically optimized for simulation. To address that second challenge, Cadence created Millennium. Millennium is a hardware software solution that combines GPU-resident solvers, CFD solvers currently, with hardware that's been co-optimized with the major hardware OEMs to deliver a turnkey, scalable, and secure solution for CFD.

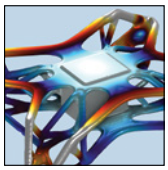
For certain types of high-fidelity CFD, a single Millennium box that you can bring into your data center and plug in has the equivalent throughput of something like 32,000 cores. That's why we call it a supercomputer. Even though its footprint is relatively small, it has the throughput equivalent of an enormous compute infrastructure.

Further than that, multiple boxes can easily be networked together. Regarding your question just about the impact of Millennium and accelerated computing on CFD, there's really two directions that the companies that we work with are exploring. The first is just to do more simulation than they currently do faster.

This produces more data and can feed optimization and even build AI models that rely on large amounts of data for training. The other direction to go when you get an order of magnitude increase in compute is to go after simulations, typically high fidelity simulations that were previously out of reach because

Cadence's Millennium M1 supercomputer. (Image: Cadence)

Product Spotlight



MULTIPHYSICS MODELING AND SIMULATION APPLICATIONS

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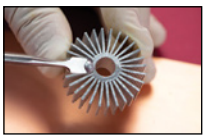

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they were cost prohibitive. A really good example in aerospace here is predicting aircraft stall at a high angle of attack.

It's a really difficult problem when the plane pitches up, predicting when the flow starts to separate from the wings and lift falls off has been challenging for traditional CFD approaches at any scale. High fidelity approaches enabled with hardware like Millennium are enabling companies to predict this accurately and robustly and to complement their testing in flight testing and wind tunnel testing.

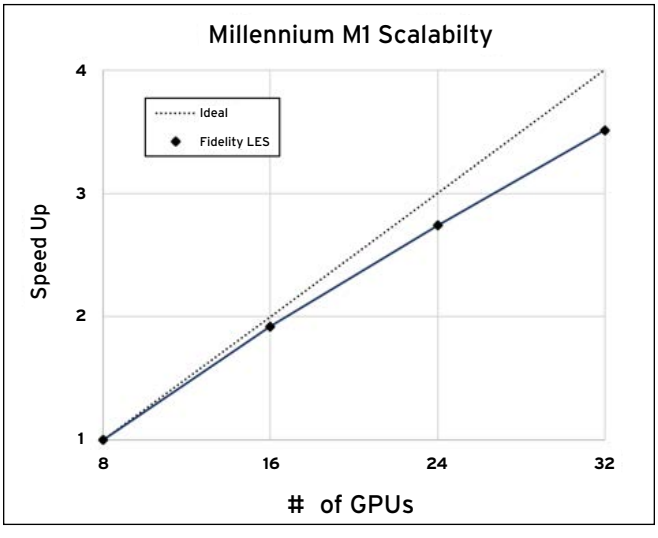
A&DT: **In the U.S., the Department of Defense has embraced a shift to the concept of "digital engineering" within its acquisition process for new technologies. As an example, in May 2024, the U.S. Army published a memorandum outlining its focus on shifting from the traditional "design, build, test" method toward a "model, analyze, build" approach. How could a CFD supercomputer help enable this shift?**

Ham: The word that really stands out to me there is shift. Inside Cadence, we like to use the term "shift left." It refers to the early integration of more model-based engineering in the design process. We, of course, believe that shift left can offer incredible value in both design and sustainment, maturation of products, as more simulation is integrated into the decision-making process earlier and all the way along.

Now it's easy for me to say that. But if this shift is so valuable, why hasn't everybody already jumped in?

I think the reasons are fairly straightforward, and Millennium certainly helps to address some of them. First of all, there is an issue with simulation of accuracy.

Simulations are not mother nature. They're just virtual versions of mother nature, and they're imperfect. But they need to be sufficiently accurate and trustworthy to be actionable.



A graph created by Cadence to show how Millennium M1 is scalable and can be deployed in configurations with more processing power and a higher number of GPUs. (Image: Cadence)

And in many cases, traditional CFD has not been. But high fidelity methods enabled by accelerated computing platforms like Millennium have the potential to change this. And that's in fact being demonstrated by some of the customers using this approach.

For other simulations, it's not just accuracy that was the issue, but also throughput. Throughput was simply insufficient to properly explore the design space. So in this case, Millennium, with its dramatic increase in throughput for even traditional methods, helps to address this bottleneck.

And as I mentioned previously, this more rapid production of data can support the training needs of data-driven models, or AI models, and further improve the design and optimization process all through the life cycle by building real-time digital twins fully capable of assimilating data from many sources and following products. So I think it's not a panacea, but Millennium addresses these two really important issues with this shift that has to occur.

For more information, visit www.cadence.com.

Listen to this podcast with Frank Ham

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The Unusual Machines *Approach to Low-Cost Drones and Drone Components*

Headquartered in San Juan, Puerto Rico, Unusual Machines describes itself as a "classic American technology company born from garage tinkerers and hobbyists, focused on serving the emerging drone industry with unique and innovative products." The company recently launched a new low-cost flight controller for drones, the Riot Brave F7, that achieved "Blue UAS" certification from the Department of Defense's (DoD) Defense Innovation Unit (DIU) in August.

The Riot Brave F7 — just $58 — features a STMF722RET6 processor equipped with Bosch accelerometer and barometer, and has 16Mb of built in Blackbox Memory. While the company developed Riot Brave F7 primarily as a low cost flight controller option for FPV drones, there are broader possibilities for it, including military applications.

Over the last year, the DoD launched its new "Replicator" initiative, which is focused on the deployment of thousands of new low-cost or "attributable" autonomous systems such as drones. On this episode of the podcast, Evans provides some perspective on Replicator, how the war in Ukraine is reflecting the effectiveness of low-cost modified drones in modern warfare, and the future of low-cost drones and drone components manufactured in the U.S.

Check out our question and answer session with Allan Evans, CEO of Unusual Machines, from his appearance on the Aerospace & Defense Technology podcast as he explains why the Brave F7 is a significant milestone in their first steps toward manufacturing embedded components for drones in the U.S.

Serhii/Adobe Stock

Aerospace & Defense Technology (A&DT): **Unusual Machines launched the new Rotor Riot Brave F7 flight controller, which was eventually approved for inclusion on the Blue UAS framework list. What is that controller and how does it work?**

Allan Evans: Flight controllers are the computer that takes the commands from the pilot and tells everything what to do to fly where you're trying to go. That, we think that it's very important, and it's one of the critical components for the U.S. government to review for drones. So we think the Defense Innovation Unit, which maintains the Blue UAS list, does a really good job of auditing.

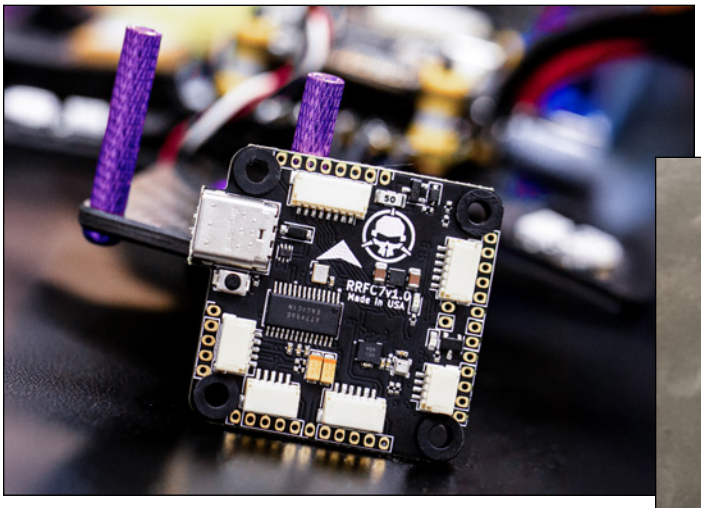
We thought, okay, we know what this should be, etc. Let's go get it audited. We worked very closely with them to get it approved.

Really what we have here is sort of the value drone brain. You might hear of NVIDIA or some of these others doing these really high-end drones. But there's a huge market for, attritable drones, especially with the Replicator initiative.

There's a real focus on cost. Also in Ukraine, they're using Chinese components that are equivalent to this flight controller.

And we're actually able to make it in the United States and sell at the same price as the Chinese equivalent. We're really trying to drive value here and quality. The real potential customers, and actually where we have orders already, is that we're shipping more than a thousand a month to Europe for use with FPV drones in Ukraine.

But really anyone wanting to build attritable FPV systems, these are just at much better value and solve the problem than any alternatives. So if the Marines want to mimic some of what Ukraine's doing, they might buy some of these to build it. Red Cat Holdings, for instance, this would work there and it creates this really competitive cost basis for drones that may only be used once, you know, where you don't want to put a ton of money into it.



Left: Unusual Machines' Rotor Riot Brave F7 Flight Controller, pictured here, achieved Blue UAS Framework certification last year. The company is seeing interest in the low cost controller for military applications of FPV drones. (Image: Unusual Machines)

Right: A 3D-printed FPV Drone developed by Unusual Machines. (Image: Unusual Machines)

***A&DT:* What was involved in the process of obtaining a Blue UAS certification for the flight controller?**

Evans: It's sort of new. So it's maybe a little less well understood than some other certifications. The Blue UAS certification looks a lot like other certifications we're familiar with like the FCC stamp or FDA approval.

It's this review by a third party and approval. What they do for review, and this is done by the Defense Innovation Unit, is they go in and they do a cybersecurity audit and a country of origin audit. So they'll beat it up from a cybersecurity perspective to be sure that it's not leaking information or sending data anywhere it shouldn't.

They'll do this for drones and parts. But then they also rip the thing all the way down, and they look at each of the pieces that are used to build it and say, what is the risk of that piece? So they do this really comprehensive risk audit, both on cybersecurity and on manufacturability.

If you pass that risk audit, they say, okay, this very specific build is low enough risk that the government can just freely buy it and know that it's approved rather than having to get a special exception. This is a really great program because it lets all the different government agencies very quickly buy drones or drone parts that are approved.

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***A&DT:* Are you seeing interest in your new drone flight controller from the Department of Defense as part of its Replicator program?**

Evans: So, we're seeing a lot of interest in Europe right now. They have an immediate need. I talked about that a little bit earlier.

The Department of Defense interests we see is not in as a prime, but from other systems integrators. So, we're working with Red Cat Holdings on FANG, which is an FPV attritable drone. They're seeing the interests from the government directly, whereas we see the interest from them, because we want to be a supplier to everyone, rather than build a product specifically for the government.

We're seeing the interests through some of the direct government customers. The reason why we're not trying to go build a drone for the Replicator Initiative is we don't want to compete with our customers. So, whether it's motors or ties into your controller, if you're talking about AeroVironment or Kratos, or you pick your defense supplier, if they need parts from us, we're happy to provide them, but we don't want to compete with them.

I think a really big one is the recent news around Skydio. Their batteries were manufactured in China, and China then cut them off, so they have to ration batteries, and it's hurting their sales. I think that has highlighted the ability to play games with the supply chain on both sides, and is going to cause the US government and the Department of Defense to focus more, not even on the final product, but also on where the parts in the final product come from.

For more information, visit www.unusualmachines.com.

Listen to the podcast with Allan Evans

Fully Rugged Mobile PCs Provide an Edge on the Battlefield and Beyond

The Defense Advanced Research Projects Agency (DARPA) pioneered satellites, the internet, drones, and human-computer interfaces. Now that work is enabling the next round of revolutionary technologies, including artificial intelligence (AI), edge and cloud computing, and the Internet of Military Things (IoMT) for a wide variety of Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) applications.

Laptops and tablets are beneficiaries of yesterday's DARPA breakthroughs as well as enablers of today's and tomorrow's innovations. For example, ruggedized mobile PCs provide powerful new tools for asymmetric warfare by giving soldiers anytime, anywhere access to biometric information such as fingerprints and facial recognition. That information enables them to quickly determine whether a person in street clothes at a checkpoint is a civilian or combatant. This application also highlights the fundamental role of edge computing and the cloud for securely storing and sharing that biometric information.

Another example is IoMT devices such as wearable sensors that monitor the location and health of soldiers for applications such as blue force tracking, and drone-mounted sensors such as thermal video cameras. Mobile PCs provide officers, drone pilots, and other users with secure access to this tactical and personnel IoMT data so they can make informed decisions. Increasingly those decisions are made with the help of generative AI, which can develop battlefield scenarios and options faster than any human.

But not just any mobile PC is up to the task. To be military grade, tablets, and laptops must be ruggedized to meet standards such as MIL-STD-810H, MIL-STD-461G, and IP66 rating, indicating protection against water and dust ingress. These certifications prove they can operate safely and reliably even in the most challenging conditions, including explosive atmospheres. They also must have sealed cases and ports, the latest state-of-the-art CPUs and other major components, a broad selection of wired and wireless connectivity options, hot-swappable batteries, and screens that remain bright and readable even in direct sunlight.

One example is IEC Infrared Systems' T360 Remote Weapon Station, used to aim and fire the M240 7.62mm medium machine gun and LWMMG .338 light machine gun. A key component is the handheld Rugged Controller Unit (RCU), which controls the weapon and camera systems and provides information such as ammunition levels. The RCU is

Curioso.Photography/Adobe Stock

The T360 with M240 on Bearcat and LTATV. (Image: Durabook)

The Durabook R8 Tablet can be integrated into a variety of legacy and new platforms. (Image: Durabook)

based on the Durabook R8 tablet, whose fully rugged specs include an IP66 rating, six-foot drop resistance, and MIL-STD 810H and ANSI/UL C1D2 certifications.

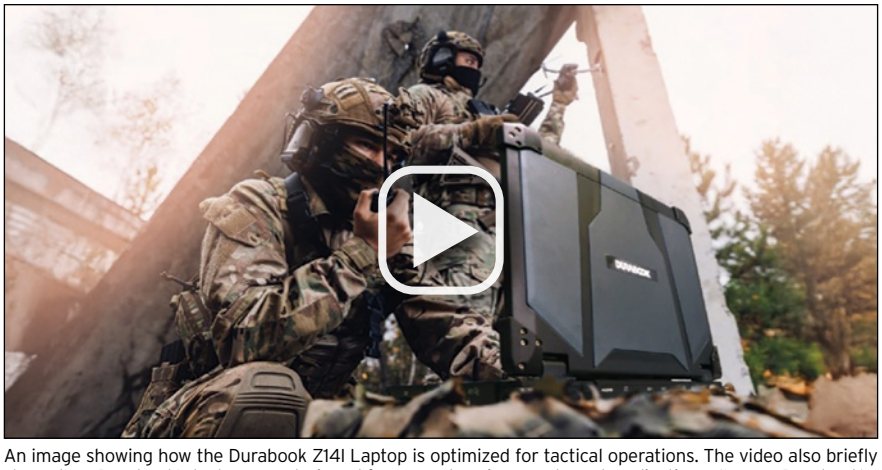
The R8 features Durabook's proprietary DynaVue® technology to ensure that the RCU's 8-inch LCD display is always viewable even in direct sunlight. The R8 also uses the Coolfinity™ passive cooling system to eliminate fans and thus ingress points for liquids, sand, and other foreign object debris. Coolfinity helps maximize battery life by reducing power consumption and extends the RCU's service life by eliminating moving parts that can eventually wear out.

Another example is Durabook rugged devices are supporting the system integrator community for short-, medium-, and intermediate-range ballistic missile threats with the ability of intercepting targets both outside and inside the atmosphere. One major anti-missile system uses the Durabook Z14I fully rugged laptop, whose specs mirror those of the R8 rugged tablet: IP66, MIL-STD 810H certification, six-foot drop resistance, and DynaVue® sunlight readable display.

The Z14I's 14-inch high-definition multi-touch screen provides a high contrast ratio and up to 1,200 nits of brightness, all of which maximizes viewing clarity from multiple angles and in both direct sunlight and low-light conditions. That's critical for defense systems that provide combat teams on the battlefield with granular tactical insights. The Durabook Z14I delivers mobile mission integrated capabilities, enhanced situational awareness, and interoperability at the tactical edge across combat teams to allow faster and more accurate leader decisions.

Finally, as Windows 11 devices, the R8 and Z14I are designed with Microsoft's Secured-core PC technology. Microsoft's Secured-core PC technology, built on firmware and dynamic root of trust measurement, shields credentials, sensitive information, and mission-critical data at the edge computing to cloud infrastructure by protecting devices against firmware-level malware attacks.

This article was written by Joe Guest, Federal President, Durabook (Fremont, CA). **For more information, visit www.durabook.com/us/defense.**

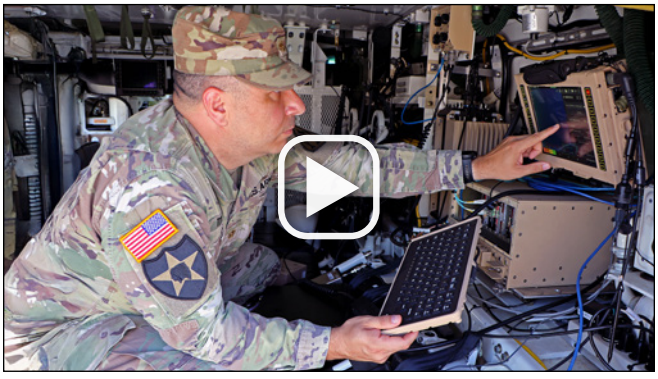


An image showing how the Durabook Z14I Laptop is optimized for tactical operations. The video also briefly shows how Durabook's laptops are designed for rugged environments and applications. (Image: Durabook)

Videos of the Month

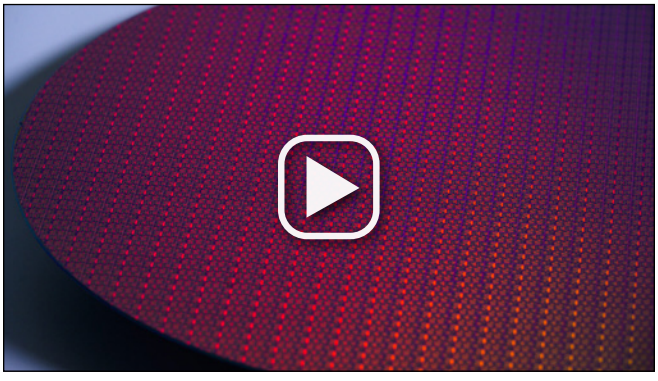
Visualizing the MOSA-Aligned Computer Chassis and Plug-in-Cards

CMFF — short for C5ISR Modular Open Suite of Standards (CMOSS) CMOSS Mounted Form Factor — is the U.S. Army's effort to more easily and rapidly equip ground vehicles and aviation platforms with capabilities like positioning, navigation, and timing (PNT), electronic warfare (EW) protection and others, through capability cards plugged into a common chassis. This video will help visualize what these designs look like based on new chassis and plug in cards that have been introduced by the global embedded computing industry in recent years.



Intel's Progress on Designing and Manufacturing Next Generation Defense Computing Chips

In January, Intel Foundry onboarded two new defense industrial base (DIB) customers, Trusted Semiconductor Solutions and Reliable MicroSystems, as part of the third phase of the Rapid Assured Microelectronics Prototypes - Commercial (RAMP-C) efforts under the Trusted & Assured Microelectronics Program in the Office of the Under Secretary of Defense for Research and Engineering. This video provides an overview of the Intel Foundry's investments and partnerships established over the last five years to expand U.S.-based manufacturing and prototyping of embedded computing modules for future aerospace and defense applications.



AUKUS Pillar II Trials Show Future of Integrated AI Operations

In a video provided by the Defense Visual Information Distribution Service (DVIDS), the Australia, UK, U.S. (AUKUS) trilateral security partnership demonstrates how artificial intelligence (AI) and machine learning (ML) could be used by warfighters in the near future. Researchers, engineers and officials from all three nations participated in the Resilient and Autonomous Artificial Intelligence Technology (RAAIT) trials as part of the AUKUS advanced capabilities line of effort, or "Pillar II."

MOSA Summit Shows Open System Architectures for Military Embedded Computing

TechConnect hosted the 2024 MOSA Summit from June 17-18 at the Gaylord Convention Center at National Harbor. In this video, Aerospace & Defense Technology highlights some of the rugged computing chassis that enable the Department of Defense's Modular Open Systems Approach (MOSA) acquisition strategy for new technologies.

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Webinars

Improving Thermal Management for Aerospace and Defense Electronics

Optimizing SWaP-C remains the key design goal of new electronics and embedded computing being developed for the enablement of artificial intelligence and machine learning in more military assets at air, land, and sea. This 60-minute webinar from the editors of *Aerospace & Defense Technology* explores new thermal management techniques that can overcome the challenges of cooling FPGAs, GPUs, and other electronic system components being deployed in military environments.

Speakers:

Ivan Straznicky
Chief Technology Officer and Technical Fellow, Curtiss-Wright Defense Solutions

Andrew Zug
Chief Engineer – ECS Architecture, Honeywell

Please visit www.techbriefs.com/webinar529

Department of Defense Contracts Denied: New Cybersecurity Rules in 2025

The Cybersecurity Maturity Model Certification (CMMC) became effective on December 16, 2024. Once the 48 CFR rule is completed, Department of Defense contracts will contain mandates for CMMC compliance. A CMMC certification validates an organization's compliance with the NIST SP 800-171r2 required 110 controls. This 60-minute webinar explores how an assessor conducts a CMMC assessment, including the types of objective evidence they may request during the assessment.

Speaker:

Robert McVay
Senior Consultant – Information Security, Smithers Services in Smithers

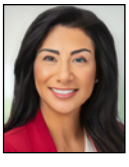
Please visit www.techbriefs.com/webinar530

Innovating Aircraft Interiors: How to Decrease Weight and Optimize Parts Production

Aircraft manufacturers face a wide range of challenges — whether it is flame, smoke, and toxicity requirements or optimizing parts production — and there are many considerations when searching for the right product for a specific production assembly or repair operation. This 60-minute webinar explores innovative adhesives and void filling materials that are designed to work with composites and engineered alloys to achieve weight savings as well as how advanced chemistry is benefiting aircraft interiors.

Speakers:

Lee Eleuterius
Technical Service Scientist for Aerospace Adhesives, Huntsman Advanced Materials



Lucy Moore
Aerospace Operational Marketing Manager, Huntsman Advanced Materials

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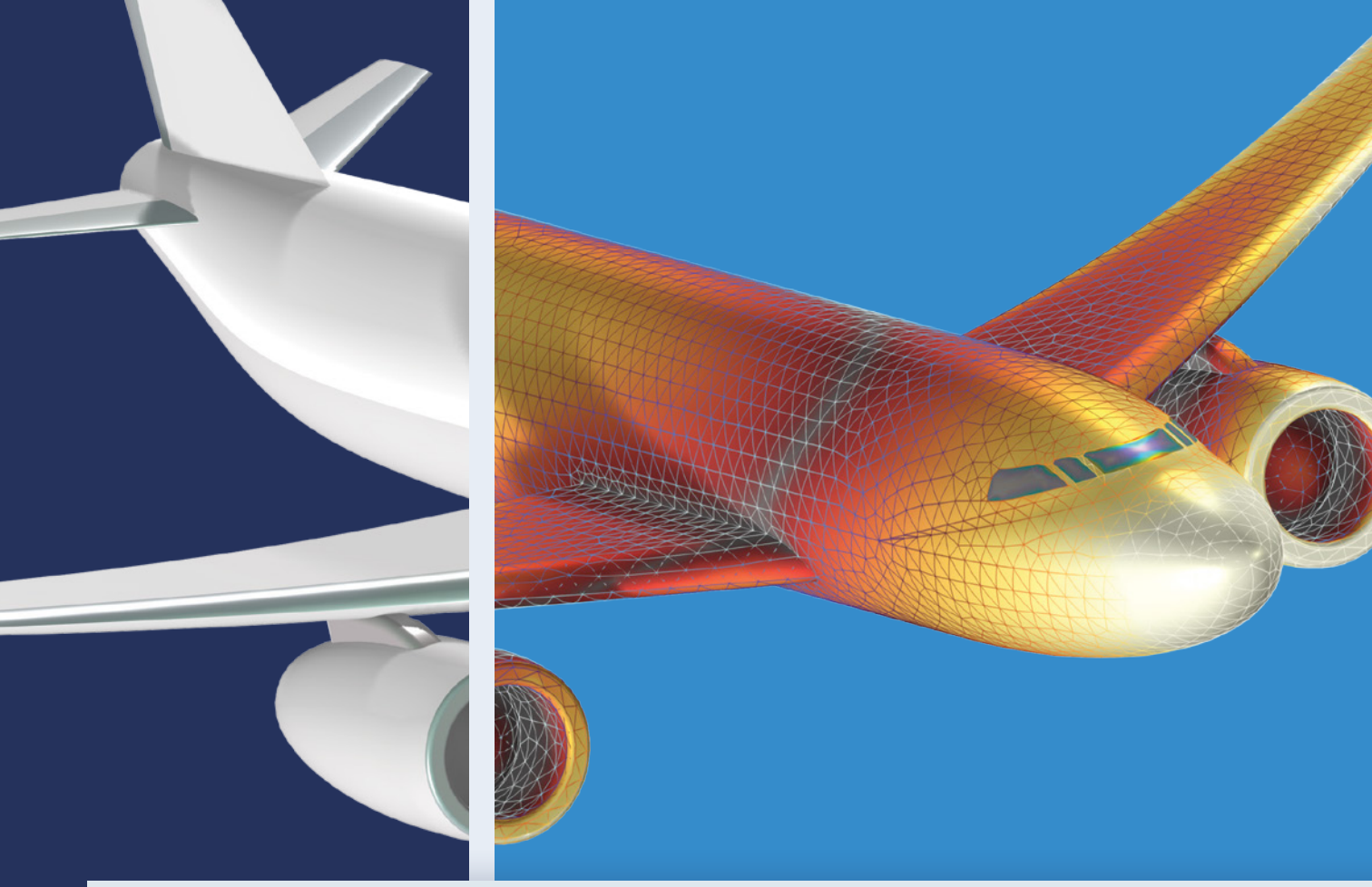

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